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Demonstration of a Standard Steel Coating System Modified with a Vapor-Phase Corrosion Inhibitor

Final Report on Project F12-AR14

Brooke A. Divan, Richard G. Lampo, and Lawrence Clark

September 2018

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Demonstration of a Standard Steel Coating System Modified with a Vapor-Phase Corrosion Inhibitor

Final Report on Project F12-AR14

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Final report

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Under Project F12-AR14, "Vapor Phase Corrosion Inhibitor Modified Coatings"

Abstract

This project demonstrated the capabilities of a vapor-phase corrosion inhibitor (VCI) as an additive into an epoxy primer coating for exterior hangar doors in a severely corrosive environment. Typically, protective coatings used on steel structures use zinc-loaded primers to provide corrosion protection to the substrate. As a more environmentally friendly option, a VCI-modified coating system has been used instead of a zinc-containing primer. The VCI migrates to the steel substrate to form a microscopically thin, corrosion-inhibiting film. The demonstrated coating system was also applied to test panels exposed to atmospheric weathering and to laboratory salt-fog exposure testing. The VCI-modified coatings were applied to abrasive-blasted substrates and to surfaces without the rust fully removed. Although the VCI-modified coating system showed promise in the test panel exposure results—especially panels with a lower grade of surface preparation—it was unable to protect the steel doors due to high levels of mechanical damage they incur during normal site operations. Based on the test panel results, further evaluation of the VCI-modified coating system is considered necessary before making a positive recommendation for Army and DoD implementation. Due to the results of this demonstration, the project return on investment was zero.

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Preface

This demonstration was performed for the Office of the Secretary of Defense (OSD) under Department of Defense (DoD) Corrosion Prevention and Control Project F12-AR14, “Vapor Phase Corrosion Inhibitor Modified Coatings”. The proponent was the U.S. Army Office of the Assistant Chief of Staff for Installation Management (ACSIM), and the stakeholder was the U.S. Army Installation Management Command (IMCOM). The technical monitors were Daniel J. Dunmire (OUSD (AT&L), Bernie Rodriguez (IMPW-E), and Valerie D. Hines (DAIM-ODF).

The work was performed by the Materials Branch of the Facilities Division (CEERD-CFM), U.S. Army Engineer Research and Development Center, Construction Engineering Research Laboratory (ERDC-CERL). A portion of the work was performed under contract with Mandaree Enterprise Corporation (MEC), Warner Robins, GA. At the time of publication, Vicki L. Van Blaricum was Chief, CEERD-CFM; Donald K. Hicks was Chief, CEERD-CF; and Michael K. McInerney, CEERD-CFM, was the ERDC CPC Program Coordinator. The Deputy Director of ERDC-CERL was Dr. Kiran-kumar Topudurti, and the Director was Dr. Lance D. Hansen.

The following personnel are gratefully acknowledged for their support and assistance in this project:

- Harry Falcon, Jr., Maintenance and Construction Branch Chief, Facilities Engineering Management Division, Corpus Christi Army Depot, TX
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- Susan Drozd – Chemist (retired), ERDC-CERL
- Alfred Beitelman, Chemist (retired), ERDC-CERL, for onsite inspection work during surface preparation and painting of the hangar doors.

The Commander of ERDC was COL Ivan P. Beckman, and the Director was Dr. David W. Pittman.

Unit Conversion Factors

Multiply	By	To Obtain
degrees Fahrenheit	$(F-32)/1.8$	degrees Celsius
feet	0.3048	meters
gallons (U.S. liquid)	3.785412 E-03	cubic meters
inches	0.0254	meters
mils	0.0254	millimeters
square feet	0.09290304	square meters

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1 Introduction

1.1 Problem statement

The Department of Defense (DoD) spends billions of dollars annually to prevent and control the effects of corrosion on metal infrastructure (Herzberg et al. 2014). Coatings are generally recognized as the first line of defense for protecting steel structures (Shaw and Kelly 2006). Thus, the need to validate better-performing and more cost-effective coatings is of ongoing interest within the Army and the DoD.

Coatings applied to steel structures for corrosion protection are routinely subjected to cuts and scratches during normal operations. If deep enough, these cuts and scratches expose the steel substrate to moisture and other elements that then cause corrosion. This type of routine impact creates the need for significant and continual maintenance against the effects of corrosion and paint failure on steel structures (e.g., fuel or water storage tanks, utility piping, metal buildings, and bridges).

Regular maintenance and repair of coatings is routinely deferred due to the expense and time constraints imposed by mission-required facility operations. The lack of routine coating maintenance results in the development of rust, pitting, and under-film corrosion. Such coating failures, if not repaired for an extended period, will cause significant damage that ultimately increases facility life-cycle costs.

Standard primers used on steel infrastructure located in highly corrosive environments commonly incorporate zinc, which serves as a sacrificial material at the anodic site of a corrosion cell to protect the steel substrate from metal loss. However, zinc particles in these coatings present environmental concerns and add difficulties in application. Consequently, DoD researchers have investigated alternative anticorrosive coatings with either reduced or insignificant zinc content, but that are still highly effective in terms of cost and corrosion protection.

A novel class of compounds—vapor-phase corrosion inhibitors (VCI)—is now being used in primer for anticorrosive coating systems, in part to reduce overreliance on zinc-loaded coatings. These VCI materials are liquid or solid organic amine compounds that have a high vapor pressure and

can migrate in the vapor phase to form a microscopically thin corrosion-inhibiting film on a steel substrate. This film, unlike zinc primers, inhibits corrosion at both the anodic and cathodic poles of a corrosion site.

This report documents a demonstration/validation project funded through the DoD Corrosion Prevention and Control (CPC) Program to investigate the performance and cost of using a VCI additive in a standard primer product. Such a coating has the potential to more effectively prevent corrosion damage to critical steel infrastructure and, consequently, to reduce facility life-cycle costs for the DoD and the Army.

1.2 Objective

The objectives of this project were to demonstrate and validate the corrosion-prevention performance and cost effectiveness of a standard epoxy polyamide primer incorporating a VCI, as applied to steel infrastructure components in a location characterized by high atmospheric corrosivity.

1.3 Approach

Hangar doors at Corpus Christi Army Depot (CCAD; Corpus Christi, TX) were selected to provide a robust performance test for the demonstrated anticorrosive coating system due to the highly corrosive environment near Corpus Christi Bay. CCAD has 100 heavy-duty steel hangar door leaves (see examples in Figure 1) on five separate hangars that are in need of repainting at an estimated cost exceeding \$1,000,000. The hangar doors coated in this project are subjected to frequent heavy impacts and abrasion during normal site operations. Also, performing this work on CCAD hangar doors leveraged efforts on a concurrent CPC coating demonstration that used the same type of hangar doors (Divan, Lampo, and Clark 2018).

Conventional epoxy systems in use by the DoD utilize MIL-DTL-24441 19C F-159 which includes large quantities of zinc dust. The VCI-coating system demonstrated in this project was the military detail (MIL-DTL) specification of MIL-DTL-24441/20, Formula 150, Type III epoxy primer incorporating a 2.5 weight percent of amine carboxylate type VCI additive (as provided by Surtreat Holdings, LLC under P/N C-12). The primer was topcoated with MIL-DTL-24441/31, Formula 152, Type IV intermediate

coating, and polyurethane coating meeting military performance specification (MIL-PRF) of MIL-PRF-85285 Type II, Class H. This three-coat system was applied to select hangar door leaves¹ and test panels² as follows:

- One hangar door leaf to which the surface was abrasive blasted to a near-white condition following SSPC SP-10 requirements.
- Another hangar door leaf surface was brush-off blasted (i.e., surface was not completely rust free) following SSPC SP-7 requirements.
- Steel test panels for atmospheric exposure testing and evaluation using both SSPC SP-10 and SP-7 surface preparation standards.
- Steel test panels for accelerated laboratory testing using both SSPC SP-10 and SP-7 surface preparation standards.
- As an experimental control, the demonstrated standard coating system, but without the VCI additive, was applied to two other hangar door leaves and sets of steel test panels—one surface-prepared according to SSPC SP-10 and the other prepared to SSPC SP-7 requirements.

Figure 1. Close-up view of three visible hangar door leaves at CCAD, with panel areas visible at bottom (six panels per door leaf).

¹ The term “door leaf” refers to the overall large, sliding hangar doors. Each door leaf has six steel framed panels that are welded together to form its base (later these are referred to as door panels).

² Per standard coating terminology, the term “test panel” is used here to refer to coated steel panels, which are then used for atmospheric exposure testing and accelerated laboratory testing.

1.4 Metrics

The metrics for assessing the performance of the demonstrated systems are listed below:

1. Using bare-metal coupons³ exposed to the atmosphere, assess the corrosivity level of the site at CCAD per ASTM G1.
2. Compare the ease of use and effectiveness of the VCI-modified coating system with the control coating system, as applied to surfaces with both higher and lesser levels of surface preparation, per ASTM D1654.
3. Compare the atmospheric corrosion-control performance of the VCI-modified coating system with the control coating system, as applied to test panels with both higher and lesser levels of surface preparation before application, per ASTM D1654.
4. Compare the corrosion-control performance of the VCI-modified coating system with the control coating system, as applied to test panel surfaces with both higher and lesser levels of surface preparation, after 2,000 hours of salt fog exposure in accordance with ASTM B-117.

The above-referenced standards and additional standards described below were used to execute this demonstration.

- ASTM D4417, “Standard Test Methods for Field Measurement of Surface Profile of Blast Cleaned Steel,” and SSPC-VIS I, “Guide and Reference Photographs for Steel Surfaces by Dry Abrasive Blast Cleaning,” were used in the surface preparation of the steel test panels and hangar door panels.
- The Society for Protective Coatings (SSPC) standard, SSPC-SP-7 (NACE No. 4), “Brush-Off Blast Cleaning,” was used as a standard for surface preparation on the hangar door panels and steel test panels.
- SSPC-SP-10 (NACE No. 2), “Near-White Blast Cleaning,” was used as a standard for surface preparation on the hangar door panels and steel test panels.
- SSPC-PA-2, “Measurement of Dry Coating Thickness with Magnetic Gages,” was used to measure coating thickness on the steel test panels and hangar door panels.

³ Per standard corrosion terminology, the term “coupon” is used here to refer to bare, uncoated specimens of various metals that are attached to a second outdoor exposure rack to measure atmospheric corrosivity.

- ASTM D1014, “Standard Practice for Exterior Exposure Tests of Paints and Coatings on Metal Substrates,” was used in the preparation and coating of all test panels.
- ASTM B117, “Standard Practice for Operating Salt Spray (Fog) Apparatus,” was used for salt spray testing of coated and scribed steel test panels.
- ASTM D1654, “Standard Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments,” Procedure A method 2 and Procedure B, was used in evaluating the coated and scribed test panels.
- ASTM D610, “Standard Practice for Evaluating Degree of Rusting on Painted Steel Surfaces,” was used in the evaluation of coated test panels in the unscribed area.
- ASTM G1-03, “Standard practice for Preparing, Cleaning, and Evaluation of Corrosion Test Specimens,” was used to evaluate mass loss experienced by bare metal coupons fabricated from copper, 1010 steel, and three aluminum alloys (2024-T3, 6061-T6, and 7075-T6) installed on an atmospheric corrosion test rack erected near the hangar doors, after 6 and 12 months of environmental exposure.
- ASTM B825, “Standard Test Method for Coulometric Reduction of Surface Films on Metallic Test Specimens,” was used to determine the amount of silver chloride (AgCl) deposited on the surface of a silver coupon installed on an atmospheric corrosion test rack.

2 Technical Investigation

2.1 Technology overview

VCIs are liquid and solid organic amine compounds that have a high vapor pressure and can migrate in the vapor phase to form a corrosion-inhibiting film on a metal surface. This film is monomolecular in scale and can inhibit corrosion at both the anodic and cathodic corrosion mechanism sites. The preferred VCIs for anticorrosive coatings are amine carboxylates that are applied in their solid phase and vaporize by sublimation. These classes of VCIs are strong anodic site corrosion inhibitors. (Corrosion of ferrous metals is an electrochemical reaction involving both an anode and a cathode. Dissolution of the ferrous ion occurs at the anodic site. However, since the anode and cathode must be in equilibrium, limiting the process at the cathode will reduce the overall reaction. Thus, an effective VCI will protect both the anodic and cathodic sites [Fodor 1985]).

A VCI that is incorporated in a surface-applied material, such as an oil or coating, migrates from the coating to the metal surface, forming a corrosion-inhibiting film. There are two modes of migration, as listed below:

- Migration to anodic hot spots to prevent the formation of corrosion cells under coating defects such as pinholes.
- Migration to both anodic and cathodic areas of exposed bare steel to create a film that isolates the substrate from oxygen and water required for the electrochemical activity that initiates corrosion.

A VCI's ability to inhibit corrosion at both anodic and cathodic sites should significantly enhance the corrosion performance of VCI-modified coatings. However, incorporating a VCI additive into a standard coating system first requires validation of chemical compatibility. For this demonstration, the additive was tested for compatibility with MIL-DTL-24441/19C F-159, which served both as the control coating and the basis of the VCI-modified coating system. The combined VCI/epoxy primer was tested to ensure that the VCI migrated from the coating to form an anticorrosive film on the substrate.

As noted above, the VCI used in this project prohibits corrosion at both the cathodic and anodic sites on steel by stabilizing the primary oxide film. The formulation was selected based on application and exposure testing. It

consisted of three amine carboxylates—the active ingredients—that were prepared by reacting 2-ethylhexanoic acid (C-8), decanoic acid (C-10), and dodecanoic acid (C-12) with dicyclohexylamine in equimolar quantities. This reaction is carried out at room temperature in a solvent, such as propyl or butyl alcohol, to form the VCI compound used in this demonstration. The resulting VCI has low solubility in water but is soluble in alcohol. When it's delivered in a coating and the solvent evaporates, it solidifies into a solid film, providing further corrosion resistance by inhibiting water from passing through. The low water solubility of this VCI makes it more effective at protecting cathodic reaction sites, by making a better protective seal than a water-soluble VCI. Also, the formulation used in this project was a solid with a high heat of formation, indicating its high resistance to degradation and ability to provide a permanent corrosion-inhibiting effect. Details on the development and testing of the VCI and its incorporation into the epoxy primer are presented in Appendix A.

The demonstrated VCI was mixed into the MIL-DTL-24441/20, Type III, epoxy primer. As stated, when applied to steel the VCI-modified primer inhibits corrosion at both the anodic and cathodic sites in a corrosion cell. At the anodic site, the VCI forms a complex with the ferrous hydroxide primary oxide film on the steel surface to increase its stability and inhibit further oxidation. At the cathodic site, the deposited film isolates the substrate surface from oxygen and water, prohibiting the corrosion cell from initiating.

As long as the steel substrate has no loose and flaking surface oxidation, little or no surface preparation is required. The formulation also can prevent further corrosion on previously coated and painted surfaces.

2.2 Field work

The aircraft hangars at CCAD are very close to Corpus Christi Bay (Figure 2), a location characterized by a very high degree of atmospheric corrosivity (see Appendix B). The location is highly suitable for a coatings demonstration because accelerated corrosion should help to return faster experimental results.

Figure 2. View of CCAD hangars near the Corpus Christi Bay (from CCAD 2011).

Hangar 47, the last in a row of several hangar buildings, was chosen for the test. The door panels (Figure 3 and Figure 4) painted in this demonstration are facing east. The overall condition of the doors on all hangars is very poor as a result of severe corrosion and age of nearly 70 years. CCAD is planning to perform a full restoration of the doors in the future. For demonstration purposes, however, the outside of the panels in the lower portion of 5 of the 10 door leaves on the east side (leaves 2, 3, 4, 5, and 9) were prepared and painted with VCI-modified MIL-DTL-24441/20 Formula 150 Type III. At the same time, as part of another demonstration, a self-repairing coating system was applied to panels on door leaves 6, 7, and 8 (Divan, Lampo, and Clark 2018). Panel areas on door leaves 1 and 10 were painted with the control coating system, with door leaf 1 panels prepared to the SSPC SP-10 near-white metal condition and door leaf 10 panels prepared to brush-cleaned SSPC SP-7 condition. Panels on door leaves 2, 3, and 4 were prepared to SSPC SP-10 condition, and panels on leaves 5 and 9 were prepared to SSPC SP-7 condition, as shown in the labels on Figure 3 and Figure 4.

2.2.1 Surface preparation

The hangar doors were first pressure washed to remove all soil and contaminants from the surface prior to the start of the abrasive blasting. The hangar doors were found to contain lead-based paint. Lead-abatement regulations require the use of a full containment system around the worksite during abrasive blasting. (The containment systems can be seen in Figure 3 and Figure 4).

An angular surface profile of 2–3 mils was achieved for proper improved coating adhesion. The surface profile roughness was tested using the

Testex press-on replica tape (Figure 5), which is burnished against a prepared surface and then measured with the micrometer (Figure 6) to determine the average surface profile. Additionally, the door surfaces were visually inspected for SSPC-VIS 1 comparison for compliance. Figure 7 shows doors after abrasive blasting and lead abatement. During application, surface preparation was checked to confirm compliance with minimum requirements.

Figure 3. Labels showing hangar door leaf numbers, type of coating system, and level of surface preparation as applied to panels on bottom portion of each door leaf.

Figure 4. Door 9 and 10 label information plus containment system in use during lead abatement.

Figure 5. Example of press-on replica tape.

Figure 6. Example of Testex micrometer.

Figure 7. Hangar door panels after lead abatement and abrasive blasting (in process of removing containment barrier).

2.2.2 Coating application

Once all surface preparation was completed, the coating process consisted first of a primer (Figure 8), followed by an intermediate epoxy polymer coat (Figure 9), and finished with a polyurethane top coat (Figure 10). Table 1 outlines the coatings process and door leaf numbers involved. All applications to door panels complied with Unified Facility Guide Specification (UFGS) 09 97 13.27, "Exterior Coating of Steel Structures." All coatings were also applied per the manufacturer's specifications.

Table 1. Details of coating applications to panels of specified hangar door leaves.

Door Leaf Number	Surface Preparation*	MIL-DTL-24441 Formula 150	MIL-DTL-24441 Formula 150, Modified with Vapor Phase (Demo System)	MIL-DTL-24441 Formula 152	MIL-PRF-85285, Type II, Semingloss
Door Leaf 1 (Control)	1	x		x	x
Door Leaf 2	1		x	x	x
Door Leaf 3	1		x	x	x
Door Leaf 4	1		x	x	x
Door Leaf 5	2		x	x	x
Door Leaf 9	2		x	x	x
Door Leaf 10 (Control)	2	x		x	x

*1 = SSPC-SP10; 2 = SSPC-SP7

Figure 8. Applying primer coat of MIL-DTL-24441/20 (Formula 150, Type III).

Figure 9. Applying intermediate coat, MIL-DTL-24441/22 (Formula 152, Type III).

Figure 10. Example of finished door panels with polyurethane topcoat (door leaves 2 and 3 shown from top to bottom, respectively).

Table 2 lists the coating thicknesses taken at each of the four locations (shown in Figure 11) on each of the six panels that comprise the bottom of each hangar door. Film thickness of the coated leaves was measured at the time of application and again after 12 months.

Figure 11. Thickness measurement locations, shown here on one door leaf.

Table 2. Coating thicknesses.

Test Location Number (Real Property Hangar Door Number)	Door Panel	Initial Thickness (Mils) at Measured Panel Locations			
		Loc 1	Loc 2	Loc 3	Loc 4
1 (47-20)	1	7.7	7.1	8.2	10.1
	2	10.9	11.2	15.4	10.9
	3	9.4	9.9	8.5	8.0
	4	10.6	12.5	12.5	11.0
	5	9.4	10.6	9.6	8.7
	6	10.9	7.9	7.7	9.8
2 (47-19)	1	13.9	12.0	10.2	10.0
	2	12.9	12.7	11.3	9.8
	3	12.6	12.1	11.5	12.9
	4	14.5	13.9	7.9	11.0
	5	11.2	15.1	10.6	10.6
	6	12.7	12.6	8.5	9.3
3 (47-18)	1	11.5	10.9	9.9	8.4
	2	11.3	11.8	8.3	9.1
	3	18.0	10.7	8.8	8.8
	4	11.0	12.6	10.0	12.8

Test Location Number (Real Property Hangar Door Number)	Door Panel	Initial Thickness (Mils) at Measured Panel Locations			
		Loc 1	Loc 2	Loc 3	Loc 4
	5	10.7	9.0	10.0	8.5
	6	10.5	10.2	8.4	9.3
4 (47-17)	1	13.6	12.4	8.6	8.1
	2	12.8	10.5	7.6	9.4
	3	11.6	11.9	10.0	11.5
	4	15.1	13.8	8.0	9.7
	5	13.2	11.6	8.3	9.2
	6	9.6	12.5	7.9	10.8
5 (47-16)	1	10.8	10.4	10.1	10.4
	2	12.9	10.4	9.7	13.0
	3	12.6	13.5	8.1	9.9
	4	14.5	14.9	11.4	10.1
	5	11.7	10.5	8.8	9.3
	6	9.5	8.8	6.2	8.6
9 (47-20)	1	24.2	15.1	16.9	11.6
	2	17.5	20.1	11.4	12.9
	3	12.9	17.7	15.2	13.3
	4	14.8	10.5	15.2	10.3
	5	12.1	14.4	11.9	11.4
	6	14.4	12.6	13.4	11.6
10 (47-11) (Control)	1	18.7	17.0	11.9	12.2
	2	13.9	12.3	11.8	9.7
	3	16.1	16.7	14.0	12.1
	4	19.0	13.7	16.1	12.3
	5	18.6	19.4	16.8	15.2
	6	16.6	18.5	12.4	13.5

The total coating thickness at many of the door panel locations exceeded the contract requirement of 7–9 mils. The average coating thickness also was within the required minimum parameters.

2.3 Panel testing

Test panels were exposed and analyzed at locations other than the hangar doors—at an on-site outdoor exposure test rack and at an off-site indoor test laboratory. Surface preparation and coating application were monitored and documented for each type of testing.

2.3.1 Test panel preparation

A set of 12 steel test panels that each measured 3 x 6 in. were coated with the VCI-modified coating system (demo), and a second and third set of 12 were coated with the standard coating system (control), using both the near-white and the brush-off blast surface preparations. A separate but identical set of panels were prepared: one set for outdoor exposure testing and one set for accelerated laboratory testing.

2.3.1.1 Test panel legend

The test panels were marked with four points of information to form each test panel's number, as described below:

- Letter S = Indicates “surface prep”
- First number = Type of surface prep (see subsection 2.3.1.2)
- Second number = Type of paint system (see subsection 2.3.1.3)
- Number after dash = test panel number (within set of 12)

Example: S11 is Surface Prep 1 (SSPC SP10) Paint system 1 (Control), and S22 is Surface Prep 2 (SSPC 7) Paint system 2 (VCI)

2.3.1.2 Paint system numbers

The project used two coating systems, as listed below – one being a control system and the other being the demonstrated system with the VCI additive.

1. Indicates the control system – MIL-DTL-24441, Formula 150; MIL-DTL-24441, Formula 152; and MIL-PRF-85285 Type II, Class H.
2. Indicates the VCI-modified MIL-DTL-24441, Formula 150, Rev D (VCI); MIL-DTL-24441, Formula 152; and MIL-PRF-85285 Type II, Class H.

2.3.1.3 Surface preparation numbers

1. Abrasive blast per SSPC-SP10 (NACE 2) to reach near-white metal.
2. Abrasive blast per SSPC-SP7-Modified (NACE 2-Modified) for complete paint removal only. Tightly adherent mill scale and rust may remain on the surface. Mill scale and rust are considered tightly adherent if they cannot be removed by lifting with a dull putty knife. The surface after blasting is to remain unprotected for 48 hours prior to painting. After assuring no grease or oil contamination has occurred since the initial blasting, blow off the surface with compressed air to remove any loose dust or rust that may be present since the initial blasting.

2.3.2 Outdoor testing

A test rack was installed at the demonstration site, and test panels were scribed and placed on the rack for exposure (Figure 12). (See section 3.1.3 for details and results.)

2.3.3 Laboratory testing

Coated panels were submitted for laboratory testing under salt fog conditions per ASTM B117 (see Appendix C).

Figure 12. Atmospheric exposure rack with test panels on lower portion and weather station in background.

3 Discussion

3.1 Results

The evaluation requirements are based only on the parameters defined in the metrics for this project and provide for an assessment of this VCI-modified primer, MIL-DTL-24441/20, Formula 150, Type III, in comparison to the standard epoxy primer/polyurethane topcoat coating systems.

3.1.1 Atmospheric corrosivity measurements

An assessment to establish the corrosivity of the environment at the CCAD site was completed by measuring the weight loss on five bare metal test coupons mounted on an atmospheric corrosion test rack after 6 months and 12 months of exposure at the test site. Weight loss data and the calculations are presented in Appendix B. It was determined that the corrosivity at this location is, as expected, very high.

3.1.2 Evaluation of coatings on hangar doors

After 12 months of exposure, the coating system was weathering well in areas not subjected to heavy impacts or abrasion, and no signs of oxidation were evident. However, the 12-month visual inspection identified significant scrapes and coating damage resulting from everyday operation of the hangar doors. This type of damage had forcibly scraped the entire coating film off the steel substrate in some places, in contrast to areas with nicks from tools and minor, routine bumping by equipment. Rust formation was underway wherever the coating had been scraped off to expose bare metal, as shown in Figure 13 and Figure 14 in which the white areas indicate where coating was abraded to bare metal. The monomolecular film deposited by the VCI between the base primer coat and the substrate would not be expected to survive mechanical damage to the coating if that the damage exposes bare steel directly to the atmosphere. Based on the nature of the coating damage and the observed results, the corrosion-prevention benefits of the VCI additive were not readily evident.

Figure 13. Physical damage to the hangar door deep enough that the VCI coating could not prevent corrosion of the resulting exposure of bare metal.

Figure 14. Scrapes on bottom of hangar door show that the damaged site resulted in corrosion of bare steel.

3.1.3 Evaluation of atmospheric test panels

The test panels placed on the exposure rack are shown in Figure 15 and Figure 16 after 12 months of exposure. (Note that the photo on the right in each figure is a close-up of the photo on the left.)

Figure 15. Panel S12-5, MIL-DTL-24441/20, Formula 150, Type III, (VCI-modified).

Figure 16. Panel S22-1, MIL-DTL-24441/20, Formula 150, Type III, (VCI-modified). (Note that visible “spots” are not corrosion but result from application technique.)

The 12-month evaluation of the atmospheric test panels found that all scribed areas had only minor corrosion in the form of a tight oxide film. No topcoat lifting, blistering, or undercutting at the scribe edge was observed, and no corrosion product residue was seen on the back surface of the test panels. The unscribed areas of each panel also were free of corrosion.

When assessed per ASTM 1654, Procedure A, these outdoor test panels are rated at 10 for corrosion creep⁴ from the scribe, which indicates zero creep. Even though this is a very corrosive environment, the 12-month exposure time was not considered sufficient in length to reliably project the coating system's service life.

3.1.4 Evaluation of laboratory test panels

Test panels were subjected to salt spray/fog testing for 2,000 hours per ASTM B117 and then evaluated per ASTM D1654. The complete laboratory report is in Appendix C. Table 3 shows rust swell, rust creep, and the overall rating of the corrosion after accelerated weathering.

Table 3. Test panel ratings after salt-fog exposure testing per ASTM B117.

Sample ID	Sample	Paint System Applied	Type of Surface Preparation	Rust Swell Rating 1,000 hr (mm)*	Creep from Scribe Rating 2,000 hr (mm)#	Rating for Unscribed Areas+
S22-7	1	VCI-modified	SSPC SP-7	5 (3.45)	10 (0.00)	10
S22-9	2	VCI-modified	SSPC SP-7	5 (3.47)	10 (0.00)	10
S21-5	5	Control	SSPC SP-7	6 (2.56)	5 (3.14)	10
S21-12	10	Control	SSPC SP-7	6 (2.32)	10 (0.00)	10
S11-5	4	Control	SSPC SP-10	6 (2.24)	4 (5.13)	10
S11-7	6	Control	SSPC SP-10	5 (4.18)	5 (4.27)	10
S12-1	7	VCI-modified	SSPC SP-10	5 (3.07)	5 (4.88)	10
S12-10	8	VCI-modified	SSPC SP-10	5 (4.34)	5 (4.56)	10
*per ASTM E1654, Procedure A, modified # per ASTM E1654, Procedure A + per ASTM D1654, Procedure B (which refers to ASTM D610 for the rating).						

Using data from Table 3, Table 4 offers a simplified comparison of ratings for rust swell⁵ and corrosion creep for four VCI-modified coating panels and four control panels, as assessed per ASTM 1654, Procedure A. Table 4

⁴ Corrosion creep is defined as the distance from the center of the scribe to the edge of the rust after the area is scratched clean per ASTM D1654, Procedure A after 2,000 hours exposure. Also note that per ASTM D1654, a numerical rating of 10 is the highest rating (meaning no rust is present). At the other end, a numerical rating of 0 means that the measured rust creepage was greater than 16 mm.)

⁵ Rust swell is defined as the distance from the center of the scribe to the edge of the rust prior to the area being scratched clean per Procedure A. The rust swell analysis was done at 1,000 hours in order to not damage the 2,000 hour data. Also note that per ASTM D1654, a numerical rating of 10 is the highest rating (meaning no rust is present). At the other end, a numerical rating of 0 means that the measured rust creepage was greater than 16 mm.)

shows that the MIL-DTL-24441, Formula 150, Rev D (VCI-modified) paint system outperformed the control paint system when applied over test panels prepared to the SSPC SP-7 condition and performed approximately the same over test panels prepared to the SSPC SP-10 condition.

Table 4. Comparison of test panels by surface preparation type for rust swell and creep ratings.

Type of Coating	Rust Swell Rating (at 1,000 hr)	Creep Rating (at 2,000 hr)
<i>Comparisons for near-white surface preparation</i>		
VCI additive	5	5
VCI additive	5	5
Control	6	4
Control	5	5
<i>Comparisons for brush-off surface preparation</i>		
Control	6	5
Control	6	10
VCI additive	5	10
VCI additive	5	10

The results of the ASTM B117 testing show that the MIL-DTL-24441, Formula 150 Rev D (VCI) paint system outperformed the control paint system when applied over panels prepared to the SSPC SP-7 condition and performed approximately the same over panels prepared to the SSPC SP-10 condition.

3.2 Lessons learned

There were no significant issues or problems involved with incorporating the VCI additive when mixing the components for the epoxy primer or with applying the complete coating system on the hangar doors. All work, including lead abatement within a containment structure, was essentially the same as for any other comparable coating project.

One important lesson learned, however, was the overestimation of the VCI-containing coating's capability to prevent corrosion when given the high level of mechanical abuse these hangar door leaves are subjected to in everyday use. The results make it obvious that the polyurethane coating

system (with or without the added VCI) is not sufficiently tough enough for the demonstrated application.

The project results also demonstrate the need to assess corrosion prevention relative to the degree of defects (such as pinholes and scratches) and to varying levels of exposure corrosivity as well as to determine effects that the degree of surface preparation has on the overall performance of a VCI-containing coating. These needs could be true for other types of coating systems besides an epoxy primer and urethane topcoat system.

4 Economic Summary

4.1 Costs

Total project costs were \$408,500, as shown in Table 5. An estimated breakdown of costs for the field demonstration portion of the project is shown in Table 6.

Table 5. Breakdown of total project costs.

Description	Amount, \$K
Labor (including \$25k from CCAD DPW)	128.1
Contract for Field Demonstration*	240.4
Travel	20.0
Reporting	15.0
Air Force and Navy participation	5.0
Total	408.5

* Includes \$56.5k provided by CCAD for coating application contract.

Table 6. Project field demonstration costs.

Item	Description	Amount, \$K
1	Labor for project management and execution (including \$20K from CCAD)	78.9
2	Travel for project management and execution	15.0
3	Cost for coatings and preparation materials	12.5
4	Subcontract for formulation	72.5
5	Contract for coating application (from CCAD)	56.5
6	Paint waste removal (CCAD DPW)	5.0
	Total	240.4

4.2 Return on investment computation

The return on investment (ROI) for this technology demonstration was computed using methods prescribed by Office of Management and Budget (OMB) Circular No. A-94, *Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs* (OMB 1992).

The VCI-modified coating system as demonstrated under this project is not being recommended for use on facilities that see the degree of mechanical damage that is experienced on the hangar door leaves at CCAD.

The estimated return on investment (ROI) in the original project management plan (PMP) assumed the following:

- Painting 100 hangar doors at an estimated total cost of \$1.15M.
- The hangar doors coated with a “standard” coating would need to be repainted every 5 years.
- The hangar doors coated with the self-repairing coating system would not need to be repainted for 19 years.

Given a total planned project execution cost of \$1M, the originally calculated ROI was 6.1. However, since the demonstrated VCI-modified coating system did not perform any better than the “standard” coating system, the assumed benefits of extending the repainting cycle would not be realized and the final ROI for the overall Project would, therefore, be zero.

However, the salt-fog panel exposure testing indicated some possible benefit for use in highly corrosive environments and for use over a surface preparation that has visual, but tightly adhering rust. Further investigation is required to verify this benefit for these types of conditions. Assuming these benefits are verified by additional evaluations, a “projected” ROI can be calculated, as presented in an example case outlined in subsections 4.2.1–4.2.4.

4.2.1 General assumptions for example case’s projected ROI

Coating steel tanks is another common anticorrosion strategy on Army installations. Assume that three elevated steel water tanks are located in highly corrosive, tropical environments (with high UV), and one tank will be coated per year. The investment required includes the total project costs shown in Table 3, plus an estimated \$200,000 to conduct the follow-on verification of benefits from using the VCI-modified coating system. Therefore, the total investment required is estimated at \$608,500.

4.2.2 Alternative 1 (baseline scenario for example case)

Each steel water tank is to be coated with a standard epoxy primer and intermediate coating, with a polyurethane topcoat for UV protection. The surface is prepared to a near-white metal blast. The total cost of painting is \$1,200,000 per tank. After 10 years, each tank will require maintenance painting at \$100,000 per tank. The coating system will require complete

removal and recoating but not until after 20 years (again costing \$1,200,000 per tank).

4.2.3 Alternative 2 (demonstrated technology for example case)

Each steel water tank is to be coated with the VCI-modified coating system, where the surface preparation is only to a brush-off blast standard (not the more-costly, near-white metal blast cleaning). The cost of painting using the less costly surface condition would be lower at \$1,000,000 per tank, which is a savings of 200,000 per tank. After 25 years, the tanks with the VCI-modified coating system would require only minimal maintenance painting at \$50,000 per tank, which is a savings of \$50,000 per tank over the baseline scenario.

4.2.4 Projected ROI for the example case

Assuming an evaluation is completed and that the results validate the potential performance benefits indicated in 4.2.3, the calculated ROI would be 2.38 (Table 7).

Table 7. Projected ROI for example case with VCI-modified coating system.

Investment Required					608,500		
Return on Investment Ratio					2.38	Percent	238%
Net Present Value of Costs and Benefits/Savings					2,648,475	4,096,290	1,447,815
A Future Year	B Baseline Costs	C Baseline Benefits/Savings	D New System Costs	E New System Benefits/Savings	F Present Value of Costs	G Present Value of Savings	H Total Present Value
1	1,200,000		1,000,000		934,600	1,121,520	186,920
2	1,200,000		1,000,000		873,400	1,048,080	174,680
3	1,200,000		1,000,000		816,300	979,560	163,260
4							
5							
6							
7							
8							
9							
10							
11	100,000					47,510	47,510
12	100,000					44,400	44,400
13	100,000					41,500	41,500
14							
15							
16							
17							
18							
19							
20							
21	1,200,000					289,800	289,800
22	1,200,000					270,840	270,840
23	1,200,000					253,080	253,080
24							
25							
26			50,000		8,610		-8,610
27			50,000		8,045		-8,045
28			50,000		7,520		-7,520
29							
30							

5 Conclusions and Recommendations

5.1 Conclusions

According to the metrics stated in section 1.4 of this report, the demonstrated VCI-modified coating was found to perform more effectively than the control coating over steel that had been treated with less surface preparation. However, the full extent of improvement in the coating's performance could not be determined during the project's limited 12-month assessment period. It is now apparent that longer-term monitoring and assessment would be needed to fully quantify the improvement that can be provided by the demonstrated VCI additive when blended into a standard MIL-DTL coating system.

5.2 Recommendations

5.2.1 Applicability

Currently, the authors do not recommend use of the demonstrated product unless its efficacy and a positive return on investment can be validated through further study and testing.

5.2.2 Implementation

This product is not recommended for implementation. Additional assessments are required before a recommendation can be offered. The demonstration reveals that the polyurethane coating system, with or without the added VCI, is not sufficiently tough for the demonstrated application, but it might be useful in areas of lower mechanical damage wherein the VCI can overcome the corrosion.

5.3 Future work

Suggested follow-on work should focus on monitoring and quantifying the coating system's anticorrosive capabilities over an extended period of

time.⁶ Of particular interest would be an investigation of why the demonstrated coating system appeared to perform better on a panel with less surface preparation, since it is basic knowledge that high-quality surface preparation provides the best conditions for coating adhesion and performance. It also would be beneficial to further study this coating system in suboptimal conditions where surface preparation cannot be maintained prior to coating application (extreme environments) or on areas that cannot be properly blasted due to structural design or environmental constraints.

The project results also demonstrate the need to assess corrosion prevention relative to the degree of defects (such as pinholes and scratches) and to varying levels of exposure corrosivity as well as to determine effects that the degree of surface preparation has on the overall performance of a VCI-containing coating.

⁶ Per email communication dated 11 Sep 2018 from Mr. Robert Walde, Surtreat Holding, LLC, the CERL authors were informed of some follow-on activities that are germane to the evaluation of the VCI-modified epoxy primer in corrosive environments. Of first note, Surtreat Holding, LLC has formed a new company, VCI Coatings, LLC, to market a VCI modified primer coating based on the primer coating used in this demonstration project. A Technical Data Sheet (TDS) of their VCI primer coating is provided in Appendix D of this report. As performed by KTA Tator, results are shown in this TDS for 1,000 hours salt-fog exposure of 4 mil thicknesses of the VCI-modified primer compared to unmodified primer, both over rust-covered steel. The VCI-modified primer showed significantly better results against rust undercoating compared to the unmodified primer. Secondly, VCI Coatings has contracted with NASA's Kennedy Space Center Corrosion Technology Laboratory to perform evaluations of their VCI Primer on white metal -cleaned and rust-covered steel exposed oceanside at the Center. The corrosion rate of steel at Corpus Christi Army Depot was recorded as 167 μm per year (very high) per this Demonstration, compared to a reported 1070 μm per year (extreme) corrosion rate at NASA/KSC oceanside. Since the exposure testing at NASA/KSC is still ongoing, results are not available to be included in this report. VCI Coatings should be contacted for future results.

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Appendix A: Report on Development of the Vapor Phase Inhibitor Coating System

FINAL REPORT

VAPOR PHASE CORROSION INHIBITOR COATING SYSTEM

BY
SURTREAT HOLDING, LLC
437 GRANT ST.
PITTSBURGH, PA 15219

TO
MANDAREE DEVELOPMENT , LLC
812 PARK DRIVE
WARNER ROBINS. GA 31088

TASK ORDER
W9132T-SUR-002
W19132T-D-0007
12T0036

DATE ISSUED
SEPTEMBER 28, 2012

REPORT DATE
SEPTEMBER 28, 2013

PREPARED BY
ROBERT WALDE
PRINCIPAL INVESTIGATOR

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EXECUTIVE SUMMARY

Surtreat Holding, LLC (Surtreat) has formulated vapor phase migratory corrosion inhibitors (VCI) for use on reinforced concrete structures to inhibit rebar corrosion. The idea for adding VCI agents to metal protective coatings to enhance corrosion prevention was presented to the U.S. Army Engineers Research and Development Laboratory, and a contract was awarded to Surtreat through Mandaree Development, LLC to investigate how this could be accomplished.

The contract specified two frequently used military specified coatings for use in the investigation.

- Epoxy Amide Primer meeting MIL-DTL-24441/20, Formula 150, Type III
- Two Component Polyurethane top coat meeting MIL-PRF-85285, Type III

Surtreat with the assistance of Shore Corporation (Shore) synthesized a series of amine carboxylate type VCI agents and examined how they could be added to the two specified coatings. Addition to the epoxy primer was accomplished by dissolving the VCI agents in N-butyl alcohol, a solvent that is used in Part A of the two part epoxy primer. Attempts to add the VCI agents to the polyurethane top coat were not successful due to a lack of compatibility. Coating of steel surfaces with the N-butyl alcohol VCI solutions was also investigated, but did not show a significant improvement in corrosion resistance and surface adhesion was reduced. For these reasons most of the formulation and performance tests were focused on the epoxy primer on smooth and abraded steel panels in both pristine and corroded states. Performance evaluation was effected by loss coating adhesion on smooth and pristine steel panels in comparison to high levels of adhesion on abraded and corroded panels.

Three types of amine carboxylate VCI agents were synthesized and formulated as 40 weight percent N-butyl alcohols solutions. The solutions were added to the epoxy primer in amounts that when Parts A and B were combined and the coating applied to a metal surface the resulting dry film solids would contain 2 to 3 weight percent of the VCI agent.

Performance testing was performed by Matco Services, Inc. under a contract with Surtreat. Surtreat sent the 40Wt. % VCI solutions to Matco and they added them to Part A of the epoxy primer and then applied the coating to steel test panels that had been abraded using black beauty and corroded by exposure in a salt fog chamber. The three VCI agent alcohol solutions delivered are identified as Types 8, 10 and 12. The epoxy primer with and without VCI added was sprayed on steel test panels and then exposed for 500 hours in the salt fog chamber ASTM B117. Performance was determined by measuring the degree of creep from a X scribed area per ASTM D1654 and the degree of rust formation on both sides per ASTM D610.

The following table presents a general summary of the results obtained using the best performing VCI, Type 12, at the best dry film concentration of 2.5 Wt. %. Detailed test results are presented in the full report.

COATING AND TEST PANEL CONDITION	DEGREE OF CREEP	DEGREE OF RUST FORMATION	
		X SCRIBED SIDE	FLAT SIDE
WITHOUT VCI/ABRADED-PRISTINE	5	1	4
WITH VCI 12/ABRADED-PRISTINE	7	6	9
WITHOUT VCI/ABRADED-CORRODED	3	1	3
WITH VCI 12/ABRADED-CORRODED	6	6	9

Degree of creep on scale of 0 to 10, 10 = no creep, 0 = 5/8 in. or more

Degree of rust on scale of 1 to 10, 1= 50%, 10=0.01%

Coating adhesion was rated at 5A (no loss) on the surface abraded panels. The resistance to corrosion by VCI addition on the test panels that were first exposed in the salt fog chamber is a significant result. The VCI is able to penetrate the rust layer and inhibit further corrosion at the nascent metal surface.

Fifty gallons of the epoxy primer plus the Type 12 VCI at a concentration to yield a 2.5Wt.% of VCI in the dry film solids has been manufactured by Simco Coatings, and delivered to the Army Depot at Corpus Christi, TX for application to steel doors and further evaluation of performance.

Surtreat believes that the project has produced a modified version of the MIL-DTL 2441/20 containing the Surtreat Type 12 VCI agent that will furnish a significant improvement in performance of this epoxy primer group for preventing corrosion on both new and corroded steel surfaces at little extra cost.

I) PROJECT BACKGROUND

Surface coatings are the primary means for protecting steel from corrosion. Protection is dependent on integrity of the coating and contact with the steel surface. In spite of all the coating developments steel corrosion is still a continuing problem.

The purpose of coating steel is to insulate the surface from corrosion causing elements such as air, water, salt and acids. Corrosion inhibitors, such as chromium oxides and zinc and ferrous oxide are added to paint as solid components to act as corrosion inhibitors, and they must make direct contact with the steel surface in order to function.

The addition of a corrosion inhibitor that can migrate in the vapor phase from the paint to the steel surface can give protection from corrosion in areas where there is no contact with the steel surface such, as recessed areas and voids in the coating and at anodic hot spots in the steel.

Surtreat Holding, LLC has been using a vapor phase migratory corrosion inhibitor (VCI) for inhibiting corrosion on reinforcing steel (rebar) in concrete structures. Surtreat uses an amine carboxylate type of VCI in both surface-applied and admixture type of rebar corrosion inhibitor formulations. The idea of adding a VCI to a steel protective coating was brought to the U.S. Army Engineer Research and Development Laboratory. A contract was awarded to Surtreat Holding through Mandaree Development Corp. to investigate the methods and benefits for addition of the Surtreat VCI agent to steel protective coatings, and to supply a quantity of a coating system for application to steel doors at the Corpus Christi, Texas U. S. Army Depot. This is primarily a R&D contract even though a paint plus VCI supply is a component. Most of the work has involved developing the best way to add VCI agents to paint in an economic manner without having any negative impact on the coating properties, and methods for measuring the beneficial performance of the VCI agents on corrosion control.

Shore Corp, a Pittsburgh company, is a cooperating partner in the R&D effort. Shore manufactures the Surtreat VCI agents and they made several new versions for use in the project.

Matco Services, Inc., a Pittsburgh company, was contracted to perform the evaluation tests on the coatings using the paint plus VCI agents that Surtreat delivered to them. They applied the paints to steel panels and exposed them in a salt fog chamber and then measured the corrosion resistant properties of coatings with and without VCI added. All work was done in accordance with ASTM standard procedures.

The following report describes the preparation of the VCI agents and the process developed for addition to a two part polyamide epoxy primer and a two part urethane paint that were specified for use by CERDL for use in the project, and the performance evaluation test performed by Matco Services.

II) SELECTION OF PAINT

The contract Statement of Work specified two types of paint for the project.

- Epoxy Amide Primer meeting MIL-DTL-2441/20 Formula 150, Type III
- Two component Polyurethane Top coat meeting MIL-PRF-85285, Type II

These two paints were purchased from a small paint manufacturer:

Simco Coatings, Inc.
211 Gunther Lane
Belle Chase, LA 70037

The epoxy amid comes in two or ten gallon kits where Part A and Part B are of equal volumes. Part A contains the polyamide adduct, the green color pigment and 25 volume percent of n-butyl alcohol as a volatile solvent. Part B contains the epoxy resin, colorless pigments and a naphtha type volatile solvent. When Parts A and B are combined a paint containing 63% solids by volume having a density of 11.25 lbs/gallon is formed.

The two part aliphatic polyurethane coating comes in 1.5 gallon kits. Part A is 1 gallon and Part B 0.5 gallons. Part A contains the polyester glycol component plus pigment and a mixture of ketone and acetate type solvents. Part B contains the polymeric isocyanate component plus volatile ketone solvents. When the two parts are combined a paint containing 51% by volume of solids is formed.

A typical coating procedure involves surface preparation of the steel or other metal surface by cleaning and surface abrasion. The green epoxy paint is applied first as a primer followed by the two part urethane as a color finish coating.

III) VAPOR PHASE CORROSION INHIBITORS

The Surtreat VCI agents are generically known as amine carboxylates. These are formed by

the reaction of an organic acid such as octanoic with an organic amine such as dicyclohexyl amine.

Three amine carboxylates were prepared by reacting 2-ethylhexanoic acid (C-8), decanoic acid (C-10) and dodecanoic acid (C-12) with dicyclohexylamine in equimolar quantities. The reaction is carried out in a solvent such as propyl or butyl alcohol and forms a solid VCI compound dissolved in the alcohol. The reaction is exothermic and results in two liquids reacting to form a solid. The three VCI compounds are identified in this report as VCI-C-8, C-10 and C-12. The solid VCI compounds have a physical property that allows them to go from the solid to vapor phase without going through the liquid phase. This property is known as sublimation.

VCI agent inhibits steel corrosion by inhibiting the cathodic and anodic mechanisms. The cathodic sites are inhibited by formation of a VCI film on the metal surface reducing contact with air and moisture. The anodic site is inhibited by formation of a VCI chemical complex with the primary iron oxide film.

VCI agents when added to paint become imbedded in the coating and migrate to the metal surface. They can migrate to areas where the coating is not in contact with the metal surface and to areas where there are defects in the coating film. If steel has rust on the surface the VCI can migrate through the rust to the fresh metal surface and inhibit further corrosion.

VCI agents are preferably put in the primer coat that is in direct contact with the metal surface and then is covered with a finish color coating that will lock the VCI into the coating system.

IV) VAPOR PHASE CORROSION INHIBITOR ADDITION TO SELECTED PAINTS

The most convenient way to add a VCI to paint is to dissolve it in a solvent that will form a high concentration solution and will be compatible with the paint formulation.

The epoxy amide and urethane paints are dissolved or thinned with butyl alcohol, naphtha, ketones, and acetates. These solvents along with an organic carbonate were tested to determine the solubility of the C-8 type VCI. This was done by adding increments of the two reactive ingredients 2-ethyl hexanoic acid and dicyclohexyl amine in 50/50 molar ratios to each solvent. When the concentration of VCI reached about 10% the solid VCI precipitated from all solution tested except alcohols. N-butyl alcohol forms a stable VCI solution at a concentration of 40 weight percent.

This was an exciting result since n-butyl alcohol is the solvent used in Part A of the green epoxy primer. It is critical that the VCI stay in solution until the curing reaction is completed. The results of the VCI solubility screening led to decision to focus most of the paint test panel preparation and exposure testing using the epoxy primer.

Forty weight percent (40%) n-butyl alcohol solution of the three VCI agents were made by reacting dicyclohexyl amine dissolve in alcohol with equimolar quantities of 2-ethylhexanoic acid (C-8), decanoic acid (C-10) and dodecanoic acid (C-12).

The 40wt. % VCI alcohol solutions were added to Part A of the two part green epoxy primer in an amount, such that when Part A and B are mixed in equal volume quantities, applied to a metal surface and allowed to dry, that the dry film will contain a known amount to the VCI solids. This amount was calculated using the solids content of Parts A and B, the density of each and the final mix of the two. The following table reports the volumes of the 40Wt.% VCI solution added to Part A to achieve a specified VCI Wt.% in the coating dry film.

TABLE 1
COMBINATION OF 40WT% VCI SOLUTION WITH EPOXY PART A BY DRY FILM VCI WT%

Milliliters VCI Solution	Milliliters Epoxy Part A	Wt. % VCI Dry Film Solids
5.0 ml	50ml	2.0
6.25 ml	50ml	2.5
7.5 ml	50ml	3.0

Addition of VCI solids to the epoxy primer paint at dry film solids content of 2 to 3 Wt. % produced a wet paint mix and a dry film with the VCI solid distributed at a molecular scale. Measurement of the dry film adhesion using ASTM D3359 showed that film adhesion was similar with and without VCI.

A surprising result was obtained in the first test set where there was a significant increase in adhesion for the corroded panels verses the fresh panels. The corroded panels had adhesion of 4B verses only 1B to 2B for the fresh panels.

An experiment was performed to determine if a VCI agent could be added to the two part urethane paint. The lack of VCI solubility in any of the solvents used in either Parts A or B of the urethane paint eliminated the use of the method used with the epoxy primer. Part A, containing the polyester glycol, was selected because it is the more inert of the two parts. The two VCI formation reactants were added to Part A in equimolar quantities and mixed.

The Parts A and B were combined and the paint applied to steel panels and allowed to dry. Inspection of the dry film showed the presence of fine particles on the surface. It is assumed that these are the solid VCI that had come out of solution during the curing and drying process. This observation led to the decision to eliminate further work on addition of VCI agent to the urethane paint. Since the urethane or any other top coating would most likely be applied over an epoxy primer with the VCI added and there would be no value for having a VCI in the top coat.

V) DIRECT APPLICATION OF VCI ON METAL SURFACE

A component of the contracted project was an examination of direct application of a VCI agent on a metal surface followed by application of paint. Steel panels were coated with the C-8 and C-10 type VCI agents dissolved in n-butyl alcohol at concentrations of 5 and 10 Wt.%. A thin wet film of each solution was applied to steel panels using a brush and allowed to dry. The resulting films were not homogeneous indicating that the VCI was coming out of solution at an uneven rate as the alcohol solvent evaporated. The dry VCI panels were delivered to Matco Services and coated with the two part epoxy primer. Matco measured the dry film adhesion and exposed them in the salt fog chamber for 500 hours. The test results indicated that paint adhesion and corrosion resistance were better than the control, but not as good as the performance obtained when the VCI is added to the epoxy primer. All panels experienced a high level of creep at the X scribed area after exposure in the salt fog chamber for 500 hours. The direct application of VCI was performed on smooth panels and better results may be obtained if run on the grit abraded panels. There was not sufficient time or funds available to explore this option, so further work on this task was terminated.

VI) PERFORMANCE MEASUREMENT TEST PROCEDURES

A) Dry Film Adhesion ASTM D3359

Adhesion is measured by cross hatch scoring the dry film and applying a special adhesive tape to the area and then rapidly removing the tape and measuring the amount of coating removed. Adhesion is rated on a scale of 5B to 1B as follows:

- 5B – None
- 4B - less than 5%
- 3B – 5 to 15%
- 2B – 15 to 35%
- 1B – 35 to 65%
- 0B – In excess of 65%

B) Salt Fog Chamber, ASTM B117

A 5% sodium chloride solution is misted on the test panels set at a 15 degrees angle at 37C (98F) for a period of 500 hours. The panels are removed , rinsed and rated for the degree of corrosion damage.

C) Evaluation of Coated Specimens Subject to Corrosive Environments, ASTM D1654

This test method measures the degree of creep of a coating from an X scribe area due to exposure to a corrosive environment such as the salt fog chamber test. Measurements are made in millimeters and given a rating number from 10 for zero creep to 0 for more than 16 millimeters of creep. (see Appendix Section)

D) Evaluation of Degree of Rusting on Painted Steel Surfaces, ASTM D610

The method is based on visual examination of test panels for the amount of surface experiencing rust beneath and through the coating surface. Rating grades are given on a scale of 10 to 0 where 10 equals less than 0.01% of surface with rust spots and 0 is 100% of the surface. The rust grade rating and reference pictures are in the Appendix Section.

E) Test method for Evaluation Degree of Blistering of Paint, ASTM D714

Similar to ASTM D610 blistering is measured on a scale of 10 to 0 except the spots showed on pictures are for blisters rather than rust spots.

VII) STEEL TEST PANELS SELECTION AND PREPARATION

Two sets of test panels were prepared and evaluated. The first set used as received ASTM A1008 carbon steel G panels. The second set used panels that were abraded with 80 grit black beauty. This was done due to the poor adhesion experienced between the smooth panels and the epoxy primer. Adhesion test on the smooth panels were in the range of 1B to 2B while the grit abraded panels had adhesion rating between 4B and 5B. The low adhesion in the first test set compromised the use of creep measurements for measuring the beneficial effect of VCI addition on smooth panels. There was no indication that the addition of VCI to the epoxy

Figure 1

SMOOTH STEEL PANELS IN FRESH AND 24 HOUR SALT FOG CHAMBER EXPOSED CORRODED

FLAT SMOOTH STEEL PANEL

SMOOTH PANEL CORRODED

primer on the smooth panel caused a decrease in adhesion it actually resulted in an increase from 1B up to 2 to 3B.

Test panels were also prepared by exposing them in the salt fog chamber for 24 hours and then removing the loose rust with an abrasive pad and rinsing and drying. This was done with both the fresh and abraded panels. Figures 1 and 2 show the fresh and corroded panels from each set. This was done to measure how the VCI would improve resistance to further corrosion on corroded and salt contaminated steel.

VIII) PAINT APPLICATION ON TEST PANELS

Part A of the two part amide epoxy primer was combined with the C-8, C-10 and C-12 VCI agents at a rate such that when combined with Part B and spray applied to the steel panels the dry film would contain 2.0, 2.5 and 3.0 Wt.% of VCI solids. Parts A and B were mixed by Matco Services and the paint sprayed on the panels and allowed to age for five days and then X scribed on side for creep measurement. The dry film thickness was measured on some of the panels and found to be in the range of 3 to 4.5 mils.

A few panels had the two part epoxy urethane paint applied over the epoxy primer to observe performance in this condition.

Five panels were prepared in most cases for every combination of panel condition and coating combination. One panel was kept for reference and or film thickness and adhesion measurements. Three to four panels from each group were put in the salt fog chamber and exposed for 500 hours.

IX) PERFORMANCE TEST RESULTS

Performance test results are presented on tables in the form of degrees of creep from the X scribed areas, degree of rust and blister formation of both sides of test panel surfaces. These measurements are related to test panel surface preparation and the type and amount of VCI added to the primer coating. These data are related to figures showing the relevant test panel surface conditions. Performance is measured relatively between the test panels with and without VCI added and the type of VCI used. It is assumed that the previous report sections have been read or will be referred to for details about how the panels were prepared and evaluated.

Three rounds of test panels were prepared and exposed to the salt fog chamber for Surtreat by Matco Services.

A) FIRST GROUP OF PAINT PLUS VCI TEST PANEL PREPARATION AND EXPOSURE

The first group had 50 panels prepared exposed and evaluated. One group of panels, in an as received smooth and pristine form, was coated with the green epoxy primer. Another group was first exposed in the salt fog chamber to form a corroded and salt contaminated surface. Loose rust was removed with an abrasive pad and then coated with the green epoxy primer with and without a VCI agent added. Epoxy primer adhesion was low (1B to 3B) on the smooth pristine panels and exposure in the salt fog chamber led to a significant loss of coating and creep at the x scribed area when put in the creep test as described in Table 2. This group also included the panel prepared to examine direct application of the VCI on steel followed by paint application, which as previously discussed did not give promising performance.

TABLE 2
Epoxy Primer Adhesion and Creep Measurements on Smooth and Pristine Panels

APPLIED COATING	ADHESION RATING	CREEP RATING at 500 hrs
Epoxy Primer	1B	0
Epoxy Primer +C-8 VCI	2B	0
Epoxy Primer + C-10 VCI	3B	0

None of these panels exhibited significant corrosion on the unscribed side so it was not possible to use this set to measure improvement in corrosion resistance due to VCI addition.

The only valuable results obtained from the first round of tests were from the panels that had first been exposed in the salt fog chamber. Both initial adhesion and creep after exposure were significantly improved. It is believed that the rough surface formed due to corrosion caused these improvements. Addition of both the C-8 and C-10 type of VCI agents resulted in a reduction in improvement in creep and surface rusting ratings after exposure for 500 hours in the salt fog chamber as reported on Table3

TABLE 3
EPOXY PRIMER PLUS C-8 AND C-10 VCI AGENTS APPLIED ON SALT FOG CORRODED STEEL PANELS

FIGURE	APPLIED COATING	ADHESION RATING	CREEP RATING	SURFACE RUST RATING	
				X SCRIBED SIDE	REVERSE SIDE
3 & 4	Epoxy Primer alone	2B	6	8	8
	Epoxy primer + C-8 VCI @ 2%	4B	6	9	10
	Epoxy primer + C-8 VCI @ 3%	3B	7	9	10
5 & 6	Epoxy primer + C-10 VCI @ 2%	4B	9	10	10

FIGURE 2

BLACK BEAUTY ABRADED STEEL TEST PANELS, PRISTINE AND CORRODED BY EXPOSURE FOR 24 HOURS IN SALT FOG CHAMBER EXPOSED

ABRADED PRISTINE

ABRADED CORRODED

FIGURE 3

SMOOTH STEEL PANELS EXPOSED TO SALT FOG FOR 24 HOURS COATED WITH GREEN EPOXY PRIMER WITH AND WITHOUT VCI ADDED
COMPARING PERFORMANCE OF C-8 VCI ADDED AT 2WEIGHT % OF DRY FILM SOLIDS

FIGURE 5

SMOOTH STEEL PANELS EXPOSED TO SALT FOG FOR 24 HOURS COATED WITH GREEN EPOXY PRIMER WITH AND WITHOUT VCI ADDED
COMPARING PERFORMANCE OF C-10 VCI ADDED AT 2WEIGHT % OF DRY FILM SOLIDS

FIGURE 6

SMOOTH STEEL PANELS EXPOSED TO SALT FOG FOR 24 HOURS COATED WITH GREEN EPOXY PRIMER WITH AND WITHOUT VCI ADDED
COMPARING PERFORMANCE OF C-10 VCI ADDED AT 2WEIGHT % OF DRY FILM SOLIDS

Figures 3, 4, 5 and 6 show the X scribed and reverse sides of the above steel panels that furnish visual verification of the ability of VCI addition to reduce the impact of a corrosive environment. The numerical and visual results show that the best performance was obtained with the C-10 VCI at 2Wt.% solids in the dry film.

B) TEST PROCEDURE REVISIONS

The difference in measured adhesion and creep between the smooth pristine and smooth corroded panels led to the decision to run future tests on abraded panels.

The lack of corrosion on the unscribed side of the test panels led to the decision to evaluate a more aggressive version of the modified salt fog chamber test (ASTM G85). A second round of path finder test were prepared using glass bead abraded panels and exposed in Annex A-1 of ASTM G85, where acetic acid is put in the water in place of salt. The results showed that a more aggressive degree of abrasion was needed to improve adhesion and creep and this version of the fog test did not increase the degree of corrosion on the panels. This led to the decision to run further tests using 80 grit black beauty abraded panels and to return back to use of the ASTM B117 salt fog test.

C) THIRD GROUP OF TEST USING BLACK BEAUTY ABRADED STEEL PANELS

A third and final round of 30 tests were performed with application of the green epoxy primer on 80 grit black beauty abraded panels and abraded panels exposed in the salt fog chamber for 24 hours. The test results show that the increase in surface area on the abraded panels increased adhesion and decreased the level of creep. The increase in surface area also resulted in a significant increase in the level of rust formation on all panels after 500 hours in the salt fog chamber.

Table 4 reports the average results for the series of test panels run comparing the effect of adding the C-10 VCI to the green epoxy primer in comparison the primer without addition of VCI. N-butyl alcohol was added to the epoxy control sample to adjust the solids content to equal that for the coating with the 40Wt. % solution of the C-10 VCI added. Both dry films had an average thickness of 2.4 mils.

TABLE 4

EPOXY PRIMER ON BLACK BEAUTY ABRADED PANELS WITH AND WITHOUT C-10 VCI ADDED EXPOSED IN SALT FOR CHAMBER FOR 500 HOURS

FIGURES	APPLIED COATING	ADHESION RATING	CREEP RATING	SURFACE RUST RATING	
				X SCRIBED SIDE	REVERSE SIDE
7 & 8	Epoxy Primer Control	5B	5.0	1	4
	Epoxy primer + C-10 VCI @ 2%	4B	6.5	5	9

FIGURE 7

BLACK BEAUTY ABRASID STEEL PANELS COATED WITH GREEN EPOXY PRIMER WITH AND WITHOUT VCI ADDED COMPARING PERFORMANCE OF C-10 VCI ADDED AT 2.5 WEIGHT % OF DRY FILM SOLIDS.

Table 5 reports results of the epoxy primer with and without VCI added when applied on black beauty abraded panels that had first been exposed in the Salt fog chamber for 24 hours to create a corroded and salt contaminated surface. The important result here is to confirm the trend in performance with respect to VCI type showing that the C-12 type is better than C-10 and previously that C-10 is better than C-8. This led to the conclusion that the C-12 type of VCI will be used in the manufacture of the two part epoxy primer Part A delivered to the Corpus Christi Army Depot. The result is also shown for the application of the polyurethane finish coat on the primer. As expected the level of corrosion resistance is further improved.

The listed figures on Tables 4 and 5 show the appearance of selected test panels with and without VCI added on both the X scribed and reverse sides. Appearance is the best evidence of performance.

TABLE 5

EPOXY PRIMER WITH AND WITHOUT VCI ADDED APPLIED ON ABRADED PANELS EXPOSED IN SALT FOG CHAMBER FOR 24 HOURS

FIGURES	APPLIED COATING	ADHESION RATING	CREEP RATING	SURFACE RUST RATING	
				X SCRIBED SIDE	REVERSE SIDE
	Epoxy Primer Control	4B	3.5	1	3
9 & 10	Epoxy primer + C-10 VCI @ 2.5%	5B	5.5	4	7
11 & 12	Epoxy Primer + C-12 VCI @ 2.5%	5B	6.0	6	9
13	Epoxy primer + C-10 VCI @ 2.5% Plus Urethane Top Coat	4B	7.0	8	9

X) CONCLUSIONS AND RECOMMENDATIONS

The performance test results show and confirm the value of adding a VCI agent to metal protective coatings. The results are limited to the amine carboxylate type of VCI agent added to an epoxy primer using alcohol in its formulation and performance after exposure for 500 hours in the salt fog chamber. The Surtreat C-12 type of VCI gave the best performance and addition of this VCI at the rate of 2.5 Wt.% in the dry film solids appears to give the best balance between corrosion resistance and impact on paint film adhesion.

The recommended paint formulation is addition of a 40Wt.% solution of the C-12 type VCI dissolved in n-butyl alcohol added to Part A of a 2 part epoxy primer at the rate of 1.25 gallons of VCI solution to 10 gallons of Part A to yield a paint mix having a 2.5 Wt.% VCI in the resulting dry film.

XI) FUTURE TECHNICAL AND SUPPLY OPPORTUNITIES

Surtreat has filed a Provisional Patent application naming Robert Walde of Surtreat Holding and Tim Knell of Shore Corp. as co inventors. This was done to protect the patent potential for loss due to disclosures or commercial use issues. Surtreat and Shore plan on taking actions to make paint

FIGURE 9

BLACK BEAUTY ABRADED STEEL PANELS EXPOSED TO SALT FOG FOR 24 HOURS COATED WITH GREEN EPOXY PRIMER WITH AND WITHOUT VCI
ADDED COMPARING PERFORMANCE OF C-10 VCI ADDED AT 2.5 WEIGHT % OF DRY FILM SOLIDS

FIGURE 10

BLACK BEAUTY ABRASDED STEEL PANELS EXPOSED TO SALT FOG FOR 24 HOURS COATED WITH GREEN EPOXY PRIMER WITH AND WITHOUT VCI
ADDED COMPARING PERFORMANCE OF C-10 VCI ADDED AT 2.5 WEIGHT % OF DRY FILM SOLIDS

FIGURE 11

BLACK BEAUTY ABRADED STEEL PANELS EXPOSED TO SALT FOG FOR 24 HOURS COATED WITH GREEN EPOXY PRIMER WITH AND WITHOUT VCI
ADDED COMPARING PERFORMANCE OF C-12 VCI ADDED AT 2.5 WEIGHT % OF DRY FILM SOLIDS

FIGURE 12

BLACK BEAUTY ABRASSED STEEL PANELS EXPOSED TO SALT FOG FOR 24 HOURS COATED WITH GREEN EPOXY PRIMER WITH AND WITHOUT VCI
ADDED COMPARING PERFORMANCE OF C-12 VCI ADDED AT 2.5 WEIGHT % OF DRY FILM SOLIDS

HEAT SIDE WITHOUT VCI

HEAT SIDE WITH C-12 VCI @ 2.5 WT. %

FIGURE 13

BLACK BEAUTY ABRADED STEEL PANELS EXPOSED TO SALT FOG FOR 24 HOURS COATED WITH GREEN EPOXY PRIMER PLUS WHITE POLYURETHANE TOP COAT SHOWING PERFORMANCE OF C-10 VCI ADDED AT 2.5 WEIGHT % OF DRY FILM SOLIDS

containing the C-12 VCI agent commercially available to the U.S. government and commercial customers. Part of this effort will involve filing a formal patent application and performance of additional technical work to expand the technology.

MEC and COE plan to use the epoxy primer with the C-12 VCI added to prepare paint panels for outdoor exposure and to coat a set of steel doors at the Corpus Christi Army Depot. The results of these exposure tests will further verify performance of paint plus VCI agent for improving corrosion protection.

Surtreat has placed an order for 66 gallons of the green epoxy primer Formula 150 containing the C-12 VCI from Simco Coatings. 50 gallons will be shipped to the Corpus Christi Army Depot along with 32 gallons of the red polyurethane finish coat and 16 gallons of a white epoxy primer Formula 152. The remaining 16 gallons of the green epoxy primer was purchased by Surtreat and will be sent to Matco Coatings for application to the black beauty abraded steel panels and panels previously exposed in the salt for chamber for further evaluation of the inhibiting properties.

The technical data sheet (TDS) and material safety data sheets (MSDS) for the 40 Wt.% VCI in n-butyl alcohol solution and the epoxy Primer Part A plus VCI are furnished in the Appendix section.

XII LIST OF TABLES

- 1) COMBINATION OF 40 WT.% VCI SOLUTION WITH EPOXY PART A BY DRY FILM SOLIDS VCI WEIGHT PERCENT
- 2) EPOXY PRIMER ADHESION AND CREEP MEASUREMENTS ON SMOOTH AND PRISTINE PANELS
- 3) EPOXY PRIMER PLUS C-8 AND C-10 VCI AGENTS APPLIED ON SLAT FOG CORRODED STEEL PANELS
- 4) EPOXY PRIMER ON BLACK BEAT ABRADED PANELS WITH AND WITHOUT C-10 VCI ADDED
- 5) EPOXY PRIMER AND POLYURETHANE WITH AND WITHOUT VCI ADDED APPLIED ON ABRADED PANELS EXPOSED IN SALT FOG CHAMBER FOR 24 HOURS

XIII LIST OF FIGURES

- 1) SMOOTH STEEL PANELS IN FRESH AND 24 HOUR SALT FOG CHAMBER EXPOSED CORRODED
- 2) BLACK BEAUTY ABRADED STEEL TEST PANELS PRISTINE AND CORRODED BY EXPOSURE FOR 24 HOURS IN SALT FOG CHAMBER EXPOSED
- 3) SMOOTH STEEL PANELS EXPOSED TO SALT FOG CHAMBER FOR 24 HOURS COATED WITH GREEN EPOXY PRIMER WITH AND WITHOUT VCI ADDED COMPARING PERFORMANCE OF C-8 VCI ADDED AT 2 WEIGHT % OF DRY FILM SOLIDS (X SCRIBED SIDE)
- 4) SMOOTH STEEL PANELS EXPOSED TO SALT FOG CHAMBER FOR 24 HOURS COATED WITH GREEN EPOXY PRIMER WITH AND WITHOUT VCI ADDED COMPARING PERFORMANCE OF C-8 VCI ADDED AT 2 WEIGHT % OF DRY FILM SOLIDS (FLAT SIDE)
- 5) SMOOTH STEEL PANELS EXPOSED TO SALT FOG FOR 24 HOURS COATED WITH GREEN EPOXY PRIMER WITH AND WITHOUT VCI ADDED COMPARING PERFORMANCE OF C-10 VCI ADDED AT 2 WEIGHT % OF DRY FILM SOLIDS (X SCRIBED SIDE)
- 6) SMOOTH STEEL PANELS EXPOSED TO SALT FOG FOR 24 HOURS COATED WITH GREEN EPOXY PRIMER WITH AND WITHOUT VCI ADDED COMPARING PERFORMANCE OF C-10 VCI ADDED AT 2 WEIGHT % OF DRY FILM SOLIDS (FLAT SIDE)
- 7) BLACK BEAUTY ABRADED STEEL PANELS COATED WITH GREEN EPOXY PRIMER WITH AND WITHOUT VCI ADDED COMPARING PERFORMANCE OF C-10 VCI ADDED AT 2.5 WEIGHT % OF DRY FILM SOLIDS (X SCRIBED SIDE)
- 8) BLACK BEAUTY ABRADED STEEL PANELS COATED WITH GREEN EPOXY PRIMER WITH AND WITHOUT VCI ADDED COMPARING PERFORMANCE OF C-10 VCI AT 2.5 WEIGHT % OF DRY FILM SOLIDS (FLAT SIDE)
- 9) BLACK BEAUTY ABRADED STEEL PANELS EXPOSED TO SALT FOG FOR 24 HOURS COATED WITH GREEN EPOXY PRIMER WITH AND WITHOUT VCI ADDED COMPARING PERFORMANCE OF C-10 VCI ADDED AT 2.5 WEIGHT % OF DRY FILM SOLIDS (X SCRIBED SIDE)
- 10) BLACK BEAUTY ABRADED STEEL PANELS EXPOSED TO SALT FOR 24 HOURS COATED WITH GREEN EPOXY PRIMER WITH AND WITHOUT VCI ADDED COMPARING PERFORMANCE OF C-10 VCI ADDED AT 2.5 WEIGHT % OF DRY FILM SOLIDS (FLAT SIDE)
- 11) BLACK BEAUTY ABRADED STEEL PANELS EXPOSED TO SALT FOG FOR 24 HOURS COATED WITH GREEN EPOXY PRIMER WITH AND WITHOUT VCI ADDED COMPARING PERFORMANCE OF C-12 VCI AT 2.5 WEIGHT % OF DRY FILM SOLIDS (X SCRIBED SIDE)
- 12) BLACK BEAUTY ABRADED STEEL PANELS EXPOSED TO SALT FOG FOR 24 HOURS COATED WITH GREEN EPOXY PRIMER WITH AND WITHOUT VCI ADDED COMPARING PERFORMANCE OF C-12 VCI ADDED AT 2.5 WEIGHT % OF DRY FILM SOLIDS (FLAT SIDE)
- 13) BLACK BEAUTY ABRADED STEEL PANELS EXPOSED TO SALT FOG FOR 24 HOURS COATED WITH GREEN EPOXY PRIMER WITH VCI ADDED PLUS WHITE POLYURETHANE TOP COAT SHOWING PERFORMANCE OF C-10 VCI ADDED AT 2.5 WEIGHT % OF DRY FILM SOLIDS (X SCRIBED AND FLAT SIDES)

APPENDIX

- Technical Data Sheet: Surtreat Type 12 VCI
- MSDS: Surtreat Type 12 VCI
- Product container label: Surtreat Type 12 VCI
- Technical Data Sheet: Polyamide Epoxy MIL-DTL-24441/20 Formula 150
Type III Plus Surtret Type 12 VCI
- MSDS: Part A MIL-DTL-24441/20
- MSDS: Part B MIL-DTL-24441/20
- Filing Receipt for Provisional Patent Application 61/842,227, July 9,
2013, Corrosion Inhibitor Paint Coating
- Product container labels: Part A and B Simco Coatings Polyamide Epoxy
Primer Product container label:
- Surtreat Epoxy Plus VCI (affixed with Simco label)
- Technical Data Sheet: Aliphatic Polyurethane MIL-PRF-85285
- MSDS: Part A MIL-PRF-85285
- MSDS: Part B MIL-PRF-85285

SURTREAT TYPE 12 VCI

TECHNICAL DATA SHEET

DESCRIPTION

Surtreat Type 12 VCI is a 40 weight percent solution in N-butyl alcohol solution of the Surtreat Type 12 vapor phase corrosion inhibitor (VCI). The VCI will migrate in the vapor phase and form a corrosion inhibiting surface on steel and other metals. Product is designed for addition to paint and other products where alcohols are compatible with the formulation.

FEATURES AND USE

Primary use is for addition to Part A of a 2 part polyamide epoxy paint or primer coating where n-butyl alcohol is a component of Part A. Surtreat Type 12 VCI is recommended for addition at the rate of 0.125 gallons (475ml) per gallon of Part A, which will yield a dry film containing 2.5 weight % of Type 12 VCI when Parts A and B are combined in a ratio of one gallon each.

PERFORMANCE

ASTM corrosion resistance measurement tests procedures have shown that and epoxy primer (MIL-DTL-24441) containing 2.5 weight % of Surtreat VCI Type 12 in the dry film solids will improve resistance to steel corrosion after exposure in salt fog chamber for 500 hours (ASTM B117) by the following degrees.

TEST METHOD	OBSERVED MEASUREMENTS			
	Fresh Abraded Steel		Corroded Abraded Steel	
	Primer Alone	Primer Plus VCI	Primer Alone	Primer Plus VCI
Creep (ASTM D1654)	5	7	4	6
Surface Rust (ASTM D610)				
X Scribed Side	1	5	1	6
Flat Side	4	9	3	9

PHYSICAL AND CHEMICAL PROPERTIES

Boiling Point: 116 C
 pH: 7-9
 Specific Gravity: 0.81
 Flash Point: 35 C
 Appearance: Colorless
 Concentration: 40 Wt.%

CAUTIONS**READ MSDS BEFORE USING**

FLAMMABLE LIQUID AND VAPOR. Breathing vapors may cause dizziness. Can cause eye and skin irritation. Use precautions when handling and blending to avoid sources of ignition and wear eye and hand protection.

PACKAGING

1 and 5 gallon pails

Surtreat Holding, LLC
437 Grant St.
Frick Building Suite 1210
Pittsburgh, PA 15219
412-281-1202

For professional use only. Not for sale to the general public

Material Safety Data Sheet

Surtreat Type-12 VCI

Section 1 - Chemical Product and Company Identification

Formula number B095**MSDS Name:** Surtreat Type-12 VCI**Company Identification:**

Surtreat Holding, LLC

1210 Frick Building

437 Grant Street

Pittsburgh, PA 15219

For information, call: 412-281-1202**Emergency Number:** ChemTel, Inc : 1-800-255-3924

Section 2 - Composition, Information on Ingredients

CAS#	Chemical Name	Percent	EINECS/ELINCS
71-36-3	n-Butyl alcohol	60%	200-751-6
N/A	Proprietary amine carboxylate	40%	N/A

Section 3 - Hazards Identification

EMERGENCY OVERVIEW

Appearance: colorless liquid. Flash Point: 35 deg C.

Primary hazards come from n-butyl alcohol carrier. No data available on amine carboxylate salt but raw material info suggest the components are eye irritants.

Warning! Causes severe eye irritation and possible eye injury. **Flammable****liquid and vapor.** Breathing vapors may cause drowsiness and dizziness.

Causes skin and respiratory tract irritation. May be harmful if swallowed.

Aspiration hazard if swallowed. Can enter lungs and cause damage. May

cause central nervous system depression.

Target Organs: Central nervous system, respiratory system, eyes, skin.

HMIS Rating

Health 2

Flammability 3

Physical 1

NFPA Rating

Health 2

Flammability 3

Instability 0

Potential Health Effects**Eye:** Causes severe eye irritation. May cause corneal edema and inflammation. May cause lacrimation (tearing), blurred vision, and

photophobia. Vapors appear to cause a special vacuolar keratopathy in humans.

Skin: Causes skin irritation. Skin absorption is slight. Repeated or prolonged exposure may cause drying and cracking of the skin. Although n-butanol can enter the circulation after topical application, the absorbed dose is insignificant compared to that from other routes.

Ingestion: May cause central nervous system depression, characterized by excitement, followed by headache, dizziness, drowsiness, and nausea. Advanced stages may cause collapse, unconsciousness, coma and possible death due to respiratory failure. Aspiration of material into the lungs may cause chemical pneumonitis, which may be fatal. May be harmful if swallowed.

Inhalation: Causes respiratory tract irritation. May cause cardiovascular disturbances, hearing abnormalities, central nervous system depression, muscle weakness, and possible death due to respiratory failure. May be absorbed through the lungs.

Chronic: Prolonged or repeated skin contact may cause defatting and dermatitis. May cause damage to the auditory nerve (some hearing loss) and vestibular injury. Animal evidence suggests that fetotoxicity and teratogenicity may be observed at doses that also cause harmful effects in the mothers. The systemic toxicity of n-butanol is low, although it may potentiate the hepatic (liver) toxicity of other inhaled compounds, such as carbon tetrachloride.

Section 4 - First Aid Measures

Eyes: In case of contact, immediately flush eyes with plenty of water for at least 15 minutes. Get medical aid immediately.

Skin: In case of contact, flush skin with plenty of water. Remove contaminated clothing and shoes. Get medical aid if irritation develops and persists. Wash clothing before reuse.

Ingestion: Potential for aspiration if swallowed. Get medical aid immediately. Do not induce vomiting unless directed to do so by medical personnel. Never give anything by mouth to an unconscious person. If vomiting occurs naturally, have victim lean forward.

Inhalation: If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical aid.

Notes to Physician: Alcoholic beverage consumption may enhance the toxic effects of this substance. Persons with liver, kidney, or central nervous system diseases may be at increased risk from exposure to this product. Butanol is especially toxic if aspirated. Treat symptomatically and supportively.

Section 5 - Fire Fighting Measures

General Information: As in any fire, wear a self-contained breathing apparatus in pressure-demand, MSHA/NIOSH (approved or equivalent), and full protective gear. Use water spray to keep fire-exposed containers cool. Flammable liquid and vapor. Vapors are heavier than air and may travel to a source of ignition and flash back. Vapors can spread along the ground and

collect in low or confined areas.

Extinguishing Media: Use water spray, dry chemical, carbon dioxide, or appropriate foam.

Flash Point: 35 deg C (95.00 deg F)

Autoignition Temperature: 343 deg C (649.40 deg F)

Explosion Limits, Lower: 1.4 vol %

Upper: 11.2 vol %

NFPA Rating: (estimated) Health: 2; Flammability: 3; Instability: 0

Section 6 - Accidental Release Measures

General Information: Use proper personal protective equipment as indicated in Section 8.

Spills/Leaks: Absorb spill with inert material (e.g. vermiculite, sand or earth), then place in suitable container. Remove all sources of ignition. Provide ventilation. Use only non-sparking tools and equipment.

Section 7 - Handling and Storage

Handling: Wash thoroughly after handling. Remove contaminated clothing and wash before reuse. Ground and bond containers when transferring material. Use spark-proof tools and explosion proof equipment. Avoid contact with eyes, skin, and clothing. Empty containers retain product residue, (liquid and/or vapor), and can be dangerous. Do not ingest or inhale. Do not pressurize, cut, weld, braze, solder, drill, grind, or expose empty containers to heat, sparks or open flames. Use only with adequate ventilation. Keep away from heat, sparks and flame.

Storage: Keep away from heat, sparks, and flame. Keep away from sources of ignition. Store in a cool, dry, well-ventilated area away from incompatible substances.

Section 8 - Exposure Controls, Personal Protection

Engineering Controls: Use process enclosure, local exhaust ventilation, or other engineering controls to control airborne levels below recommended exposure limits. Facilities storing or utilizing this material should be equipped with an eyewash facility and a safety shower.

Exposure Limits

Chemical Name	ACGIH	NIOSH	OSHA - Final PELs
n-Butyl alcohol	20 ppm TWA	1400 ppm IDLH	100 ppm TWA; 300 mg/m3 TWA

OSHA Vacated PELs: n-Butyl alcohol: No OSHA Vacated PELs are listed for this chemical.

Personal Protective Equipment

Eyes: Wear chemical splash goggles.

Skin: Wear appropriate protective gloves to prevent skin exposure.

Clothing: Wear appropriate protective clothing to prevent skin exposure.

Respirators: A respiratory protection program that meets OSHA's 29 CFR

1910.134 and ANSI Z88.2 requirements or European Standard EN 149 must be followed whenever workplace conditions warrant respirator use.

Section 9 - Physical and Chemical Properties

Physical State: Liquid
Appearance: colorless
Odor: vinous or wine-like
pH: 7 to 9
Vapor Pressure: 6.7 mm Hg @ 25 deg C
Vapor Density: 2.6 (Air=1)
Evaporation Rate: 0.46 (Butyl acetate=1)
Viscosity: 2.94 cP at 20 deg C
Boiling Point: 116 deg C
Freezing/Melting Point: -89.5 deg C
Decomposition Temperature: Not available.
Solubility: Slightly soluble.
Specific Gravity/Density: 0.8100 (Water=1)

Section 10 - Stability and Reactivity

Chemical Stability: Stable under normal temperatures and pressures.
Conditions to Avoid: Ignition sources, excess heat, confined spaces.
Incompatibilities with Other Materials: Strong oxidizing agents, strong acids, alkali metals, halogens.
Hazardous Decomposition Products: Carbon monoxide, irritating and toxic fumes and gases, carbon dioxide.
Hazardous Polymerization: Will not occur.

Section 11 - Toxicological Information

RTECS#:
CAS# 71-36-3: EO1400000
LD50/LC50:
CAS# 71-36-3:
Draize test, rabbit, eye: 2 mg Severe;
Draize test, rabbit, eye: 2 mg/24H Severe;
Draize test, rabbit, skin: 405 mg/24H Moderate;
Draize test, rabbit, skin: 20 mg/24H Moderate;
Inhalation, rat: LC50 = 8000 ppm/4H;
Inhalation, rat: LC50 = 24000 mg/m³/4H;
Oral, mouse: LD50 = 100 mg/kg;
Oral, rabbit: LD50 = 3484 mg/kg;
Oral, rabbit: LD50 = 3400 mg/kg;
Oral, rat: LD50 = 790 mg/kg;
Oral, rat: LD50 = 800 mg/kg;
Skin, rabbit: LD50 = 3400 mg/kg;

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Section 15 - Regulatory Information

US FEDERAL**TSCA**

CAS# 71-36-3 is listed on the TSCA inventory.

Health & Safety Reporting List

None of the chemicals are on the Health & Safety Reporting List.

Chemical Test Rules

None of the chemicals in this product are under a Chemical Test Rule.

Section 12b

None of the chemicals are listed under TSCA Section 12b.

TSCA Significant New Use Rule

None of the chemicals in this material have a SNUR under TSCA.

CERCLA Hazardous Substances and corresponding RQs

CAS# 71-36-3: 5000 lb final RQ; 2270 kg final RQ

SARA Section 302 Extremely Hazardous Substances

None of the chemicals in this product have a TPQ.

SARA Codes

CAS # 71-36-3: immediate, fire.

Section 313

This material contains n-Butyl alcohol (CAS# 71-36-3, > 99%), which is subject to the reporting requirements of Section 313 of SARA Title III and 40 CFR Part 373.

Clean Air Act:

This material does not contain any hazardous air pollutants.

This material does not contain any Class 1 Ozone depleters.

This material does not contain any Class 2 Ozone depleters.

Clean Water Act:

None of the chemicals in this product are listed as Hazardous Substances under the CWA.

None of the chemicals in this product are listed as Priority Pollutants under the CWA.

None of the chemicals in this product are listed as Toxic Pollutants under the CWA.

OSHA:

None of the chemicals in this product are considered highly hazardous by OSHA.

STATE

CAS# 71-36-3 can be found on the following state right to know lists: California, New Jersey, Pennsylvania, Minnesota, Massachusetts.

California Prop 65

California No Significant Risk Level: None of the chemicals in this product are listed.

European/International Regulations**European Labeling in Accordance with EC Directives**

Hazard Symbols:

XN

Risk Phrases:

- R 10 Flammable.
- R 22 Harmful if swallowed.
- R 37/38 Irritating to respiratory system and skin.
- R 41 Risk of serious damage to eyes.
- R 67 Vapours may cause drowsiness and dizziness.

Safety Phrases:

- S 13 Keep away from food, drink and animal feeding stuffs.
- S 26 In case of contact with eyes, rinse immediately with plenty of water and seek medical advice.
- S 37/39 Wear suitable gloves and eye/face protection.
- S 46 If swallowed, seek medical advice immediately and show this container or label.
- S 7/9 Keep container tightly closed and in a well-ventilated place.

WGK (Water Danger/Protection)

CAS# 71-36-3: 1

Canada - DSL/NDSL

CAS# 71-36-3 is listed on Canada's DSL List.

Canada - WHMIS

not available.

This product has been classified in accordance with the hazard criteria of the Controlled Products Regulations and the MSDS contains all of the information required by those regulations.

Canadian Ingredient Disclosure List

CAS# 71-36-3 is listed on the Canadian Ingredient Disclosure List.

Section 16 - Additional Information

MSDS Creation Date: 8/27/2013

The information above is believed to be accurate and represents the best information currently available to us. However, we make no warranty of merchantability or any other warranty, express or implied, with respect to such information, and we assume no liability resulting from its use. Users should make their own investigations to determine the suitability of the information for their particular purposes. In no event shall Fisher be liable for any claims, losses, or damages of any third party or for lost profits or any special, indirect, incidental, consequential or exemplary damages, howsoever arising, even if Surtreat has been advised of the possibility of such damages.

Carcinogenicity:

CAS# 71-36-3: Not listed by ACGIH, IARC, NTP, or CA Prop 65.

Epidemiology: No data available.

Teratogenicity: See actual entry in RTECS for complete information.

Reproductive Effects: See actual entry in RTECS for complete information.

Mutagenicity: See actual entry in RTECS for complete information.

Neurotoxicity: No information available.

Other Studies:

Section 12 - Ecological Information

Ecotoxicity: Fish: Fathead Minnow: LC50 = 1510-1730 mg/L; 96 Hr; Static bioassay at 24.7°C (pH 7.64) Water flea Daphnia: EC50 = 1980-1983 mg/L; 48 Hr; Unspecified Bacteria: Phytobacterium phosphoreum: EC50 = 2817-3710 mg/L; 5,30 min; Microtox test Release of n-butanol to soil may result in volatilization from the soil surface and biodegradation is expected to be significant. n-Butanol should not bind strongly to soil and so is expected to leach into groundwater. Release of n-butanol to water is expected to result in biodegradation and in volatilization from the water surface. Photooxidation by hydroxyl radicals is expected to be slow.

Environmental: When released to soil, substance is expected to biodegrade, leach to ground water or volatilize. In water, substance is expected to biodegrade or volatilize. Bioconcentration potential is predicted to be low. Soil Mobility: Substance is moderately to highly mobile (log octanol/ water partition coefficient=0.88).

Physical: Substance reacts in air with hydroxyl radicals (half-life=2.3 days).

Other: None.

Section 13 - Disposal Considerations

Chemical waste generators must determine whether a discarded chemical is classified as a hazardous waste. US EPA guidelines for the classification determination are listed in 40 CFR Parts 261.3. Additionally, waste generators must consult state and local hazardous waste regulations to ensure complete and accurate classification.

RCRA P-Series: None listed.

RCRA U-Series:

CAS# 71-36-3: waste number U031 (Ignitable waste).

Section 14 - Transport Information

	US DOT	Canada TDG
Shipping Name:	BUTANOLS	BUTANOLS
Hazard Class:	3	3
UN Number:	UN1120	UN1120
Packing Group:	III	III
Additional Info:		FLASHPOINT 29 C

SURTREAT TYPE 12 VCI

PRODUCT

A 40 WEIGHT % SOLUTION IN N-BUTYL ALCOHOL OF SURTREAT TYPE 12 VAPOR PHASE MIGRATORY CORROSION INHIBITOR (VCI)

USE

FOR BLENDING WITH COATINGS WHERE ALCOHOLS ARE COMPATIBLE WITH THE FORMULATION TO GIVE AN INCREASED LEVEL OF PROTECTION FROM CORROSION. MAKE TRIAL BLENDS TO VERIFY COMPATIBILITY BEFORE USING. READ TECHNICAL DATA SHEET

CAUTION

LIQUID AND VAPORS ARE FLAMMABLE

DO NOT BLEND WITH COATING OR USE NEAR IGNITION SOURCES. USE IN WELL VENTILATED AREA. READ MSDS BEFORE USING.

SURTREAT HOLDING, LLC
437 GRANT STREET
1210 FRICK BUILDING
PITTSBURGH, PA 15219
412 -281-1202

SIMCO COATINGS, INC
MANUFACTURER

SURTREAT HOLDING, LLC
SUPPLIER

Product Information

EPOXY—POLYAMIDE PRIMER GREEN

MIL—DTL-24441/20A (SH)

FORMULA 150, TYPE—III

PLUS SURTREAT TYPE 12 VAPOR PHASE CORROSION INHIBITOR

DESCRIPTION: This epoxy-polyamide, two component, lead and chromate free primer coating is designed to conform the specific composition and performance requirement of Federal Specification MILDTL-24441/20A (SH) Formula-150, Type-III, and is recommended to be used for painting land and marine structures. Surtreat Type 12 vapor phase corrosion inhibitor (VCI) added to Part A in an amount that when combined with Part B a VCI dry film solids content of 2.5 Wt. % will result.

PRINCIPAL CHARACTERISTICS:

- Excellent rust preventative properties in adverse or chemically polluted atmospheres.
- Corrosion inhibiting properties are increased by a factor of 5 to 10 times due to addition of surtreat Type 12 VCI
- Will inhibit corrosion of both fresh and salt corroded steel surfaces
- Easy application by airless spray up to 5.0 mils (150 Microns) dry film thickness.
- Good adhesion properties on steel, concrete, fiberglass and aluminum when the surface is properly prepared.
- Excellent water and weather resistance for interior and exterior use.
- Good impact resistance
- Resistance to spill/splash mild chemicals.

TECHNICAL DATA

COLOR AND FINISH:	Green, Flat
MASS DENSITY:	Approx 11.25 lbs./gal.
SOLIDS BY VOLUME:	63 ± 1%
VOC (BEFORE THINNING) :	2.80 lbs./gal. , 340 grmilt.
THEORETICAL SPREADING RATE:@ 1 MIL DFT:	Approx 1,000 sq. ft. /gal.*
RECOMMENDED DRY FILM THICKNESS:	3-4 Mils (75-100 Microns)
TOUCH DRY (25°C/77°F):	2-3 Hrs.
DRY HARD (25 °C/77°F) :	6-8 Hrs.
MIN. INTERVAL BEFORE OVERCOATING (77°F) :	8 Hrs. at 3-4 Mils DFT
MAX. INTERVAL BEFORE OVERCOAT ING :	7 Days
FULL CURE AFTER:	7 Days
TEMPERATURE RESISTANCE (DRY) :	250°F (121°C)
SHELF LIFE (COOL & DRY PLACE) :	Subject to re inspection after 12 months.
FLASH POINT (TCC) :	Base 99° F (38°C)
	Hardener 108°F (42°C)

PACKAGE : A two Component material with base and curing agent supplied in 1 and 5 Gallons Containers Mix ratio in equal volumes.

Simco Coatings. Inc., Belle Chasse, LA 70037 Surtreat Holding, LLC, Pittsburgh, PA 15219
 504-393-9455, e-mail: sales@simcocoatings.com 412-281-1202, surtreat_tony@yahoo.com

**SIMCO COATINGS INC.
MANUFACTURER**

**SURTREAT HOLDING, LLC
SUPPLIER**

EPOXY-POLYAMIDE PRIMER GREEN

MIL-DTL-24441/20A (SH)

FORMULA 150, TYPE-III

PLUS SURTREAT TYPE 12 VAPOR PHASE CORROSION INHIBITOR

RECOMMENDED SUBSTRATE

CONDITIONS:

Steel: Blast cleaned to a minimum grade SSPC-SP10 (SA2 ¹/₂) The surface must be perfectly dry.

INSTRUCTIONS FOR USE:

Power agitate base component to uniform consistency before combining, then again after combining. Do Not vary proportions.

Substrate Temperature:

During application and the first 24 hours of curing, the substrate temperature must be above 41°F (5°C) and at least 5°F (3°C) above the dew point.

Mixing instructions:

Ratio : base to hardener 54-46 by weight

base to hardener 50-50 by volume

The temperature of the mixture of base and hardener during mixing and application should be above 59 °F (15°C), otherwise more solvents must be used to obtain application viscosity. This results in lower sag resistance and slower cure. Thinner should be added after mixing the components.

Very good mechanical mixing of base and hardener is essential in view of the paste consistency.

POTLIFE:

5 Hours At 73 °F (23 °C)

CONVENTIONAL SPRAY

Manufacturer:

DeVilbiss Binks

Gun Model:

MBC or JGA #18 or #62

Tip-Air Cap Combination:

704E 66PE

Fluid hose should be 3/8" I.D. with a maximum length of 50 feet. Pot should always have dual regulation and be kept at same elevation as spray gun.

AIRLESS SPRAY

Manufacturer:

Graco Binks DeVilbiss

Gun Model:

205-590 Model 500 JGN-501

Pump:

Bulldog Mercury 5C QFA-519

Hose should be 3/8" I.D. minimum, but 1/4" whip end section may be used for ease of application. A maximum length of 100 feet is suggested. Best results will be obtained using a .018"-.021" tip at 24 p.s.

Simco Coatings, Inc
211 Gunther Ln., Belle Chasse, LA 70037, U.S.A.
504-393-9455, Fax: 504-433-1406
sales@simcocoatings.com
www.simcocoatings.com

Surtreat Holding, LLC
437 Grant St., 1210 Frick Bld, Pittsburgh, PA 15219
412-281-1202, Fax: 412-281-1282
surtreat_tony@yahoo.com
www.surtreat.info

SIMCO COATINGS, INC. SURTREAT HOLDING, LLC

MANUFACTURER SUPPLIER

EPDXY-POLYAMIDE PRIMER GREEN

MIL-DTL-24441/20A (SH)

FORMULA 150, TYPE-III

PLUS SURTREAT TYPE 12 VAPOR PHASE CORROSION INHIBITOR

THINNING REQUIREMENT:

Recommended Thinner:	MIL-24441 Thinner
Airless Spray	0-10% by Volume
Conventional Spray	5-15% by Volume
Roller And Brush	0-5% by Volume
Clean-up Thinner	MIL-24441 Thinner

CAUTION:

Contains flammable solvents. Keep away from sparks and open flames. Use only grounded explosion proof equipment in accordance with the National Electric Code. Workmen must use nonferrous tools; wear non-conductive and non-sparking shoes in areas where explosion hazards exist.

In confined areas, workmen must wear fresh airline respirators, protective clothing and gloves. Avoid contact with skin, breathing of vapor or spray mist ingestion. Keep out of reach of children.

NON-WARRANTY:

The technical data listed herein has been compiled for your convenience and guidance, and is based upon our experience and knowledge. However, since we have no control over the use of this information or of this product, no warranty, expressed or implied, is intended or given. Simco Coatings, Inc., assumes no responsibility whatsoever for coverage, performance, or any other damages, including injuries resulting from use of this information or of products recommended herein.

FOR INDUSTRIAL USE ONLY.

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surtreat_tony@yahoo.com
www.surtreat.info

MSDS for Epoxy Polyamid Primer Green (Comp. A)

MATERIAL SAFETY DATA SHEET

MANUFACTURER'S NAME: FOR 24 HOURS EMERGENCY ASSISTANCE
CALL - CHEMTREC

Simco Coatings, Inc.
211 Gunther Lane,
Belle Chasse, LA 70037

DOMESTIC NORTH AMERICA (800) 424-9300
INTERNATIONAL, CALL (703) 527-3887

DATE OF PREPARATION:
1/2/12

INFORMATION TEL. NO.: (866) 957-4626

SECTION I - PRODUCT IDENTIFICATION

PRODUCT NUMBER: MIL-DTL-24441/20A (SH) HMIS RATING:
Formula-150, Type-III
PRODUCT NAME: Epoxy Polyamide Primer Green (Comp. A) HEALTH: 2
PRODUCT CLASS: Epoxy Polyamide Paint FLAMMABILITY: 3
REACTIVITY: 0
PERSONAL PROTECTION: X

SECTION II - HAZARDOUS INGREDIENTS

INGREDIENTS	CAS #	WEIGHT PERCENT	OCCUPATIONAL EXPOSURE TLV (PPM)	LIMITS PEL (PPM)	VAPOR mm Hg @ 20° C
N-Butyl Alcohol	71-36-3	20-25	50.00	100.00	4.00

SECTION III - PHYSICAL DATA

BOILING RANGE: 244-284°F VAPOR DENSITY X HEAVIER LIGHTER THAN AIR
EVAPORATION RATE: FASTER X SLOWER THAN ETHER %VOLATILE VOLUME: 46.00 %
WT/GAL.: 11.50 VOLATILE ORGANIC COMPOUND (VOC) 3.00 Lb./Gallon or 360 Grm./Ltr.

SECTION IV - FIRE AND EXPLOSION HAZARD DATA

FLAMMABILITY CLASSIFICATION OSHA: Flammable FLASH POINT: 99°F
LEL: 1.0 DOT: Flammable

EXTINGUISHING MEDIA:

FOAM "ALCOHOL" CO2 DRY CHEMICAL WATER FOG OTHER
FOAM

UNUSUAL FIRE AND EXPLOSION HAZARDS: Keep containers tightly closed. Isolate from heat, electrical equipment, spark & open flame, closed containers may explode when exposed to extreme heat. Do not apply to hot surfaces. Paint vapors can cause a violent explosion. Supply sufficient ventilation to keep vapors below LEL level. Use explosion proof equipment.

Special Fire fighting Procedures:

Water may be used to cool closed containers to prevent pressure build up and possible auto ignition or explosion when exposed to extreme heat. If water is used, fog nozzles are required.

SECTION V - HEALTH HAZARD DATA

EFFECTS OF OVEREXPOSURE:

Inhalation: Anesthetic irritation of the respiratory tract or acute nervous system depression characterized by headache, dizziness, staggering gait, confusion, unconsciousness or coma.

MEDICAL CONDITIONS PRONE TO AGGRAVATION BY EXPOSURE:

Asthma, Infections of the respiratory system, Bronchitis, Dermatitis.

PRIMARY ROUTE(S) OF ENTRY: DERMAL X INHALATION X INGESTION X

EMERGENCY AND FIRST AID PROCEDURES:

Eyes: Flush with large amount of water.

Skin: Wash thoroughly with soap and water.

Inhalation: Remove to respiration if not breathing.

Ingestion: Keep warm and quiet. Do not induce vomiting. Consult a physician in all cases.

SECTION VI - REACTIVITY DATA

STABILITY: UNSTABLE X STABLE

HAZARDOUS POLYMERIZATION X MAY OCCUR WILL NOT OCCUR

HAZARDOUS DECOMPOSITION PRODUCTS:

Carbon dioxide, Carbon monoxide

CONDITIONS TO AVOID:

All sources of ignition and heat

INCOMPATIBILITY (MATERIALS TO AVOID):

Excessive heat after mixing components may cause fast polymerization.

SECTION VII - TRANSPORTATION INFORMATION

U.S. DEPARTMENT OF TRANSPORTATION OR INTERNATIONAL AIR TRANSPORT ASSOCIATION OR INTERNATIONAL MARITIME ORGANIZATION:

PROPER SHIPPING NAME:	PAINT	HAZARD CLASS:	3
UN OR ID NUMBER:	U.N. 1263	PACKING GROUP:	III

SECTION VIII - SPILL OR LEAK PROCEDURES

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED:

Remove all sources of ignition (flame, hot surfaces, and electrical static or frictional sparks). Avoid breathing vapors; ventilate area, removed with inert absorbent and non-sparking tools.

WASTE DISPOSAL METHOD:

Dispose in accordance with local, state and federal regulations. Incinerate in approved facility. Do not incinerate closed containers.

SECTION IX - SAFE HANDLING AND USE INFORMATION

RESPIRATORY PROTECTION: Self-contained breathing apparatus (SCBA) or other supplied-air respirator

VENTILATION: General ventilation is recommended. Additional local exhaust ventilation is recommended where vapors, mists or aerosol may be released

PROTECTIVE GLOVES: Wear impervious gloves, apron & splash goggles where exposure is possible. Launder contaminated clothing before reuse

EYE PROTECTIVE EQUIPMENT: Required for prolonged or repeated contact.

OTHER PROTECTIVE EQUIPMENT: Use of goggles or face shields is required to protect against splash of liquids.

HYGIENIC PRACTICES: Prevent prolonged skin contact to contaminated clothing.

SECTION X - SPECIAL PRECAUTIONS

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORING:

Keep away from heat, sparks, open flames.

OTHER PRECAUTIONS:

Drums stored in direct sunlight may build pressure.

MSDS Sheet for: MIL-DTL-24441, Formula-150 Type III Epoxy Polyamide Primer Green (Comp. A)

MSDS for Hardener for Epoxy Polyamid Primer (Comp. B)

MATERIAL SAFETY DATA SHEET

MANUFACTURER'S NAME: **FOR 24 HOURS EMERGENCY ASSISTANCE**
CALL - CHEMTREC

Simco Coatings, Inc.
 211 Gunther Lane,
 Belle Chasse, LA 70037

DATE OF PREPARATION: 1/2/12

DOMESTIC NORTH AMERICA (800) 424-9300
 INTERNATIONAL, CALL (703) 527-3887

INFORMATION TEL. NO.: (866) 957-4626

SECTION I - PRODUCT IDENTIFICATION

PRODUCT NUMBER: MIL-DTL-24441/20A (SH)
 Formula-150, Type-III

PRODUCT NAME: Hardener for Epoxy Polyamide Primer (Comp. B)

PRODUCT CLASS: Epoxy Paint

HMIS RATING:
 HEALTH: 2
 FLAMMABILITY: 3
 REACTIVITY: 0
 PERSONAL PROTECTION: X

SECTION II - HAZARDOUS INGREDIENTS

INGREDIENTS	CAS #	WEIGHT PERCENT	OCCUPATIONAL EXPOSURE TLV (PPM)	LIMITS PEL (PPM)	VAPOR mm Hg @ 20° C
Proprietary Epoxy Resin	N/A	50-55	N/A	N/A	-
Aromatic Solvent Naphtha	64742-95-6	20-25	100.00	100.00	3.00

SECTION III - PHYSICAL DATA

BOILING RANGE: 308-328°F VAPOR DENSITY: XHEAVIER LIGHTER THAN AIR
 EVAPORATION RATE: FASTER X SLOWER THAN ETHER %VOLATILE VOLUME: 35.00 %
 WT/GAL.: 10.25 VOLATILE ORGANIC COMPOUND (VOC) 2.60 Lb./Gallon or 310 Grms./Ltr.

SECTION IV - FIRE AND EXPLOSION HAZARD DATA

FLAMMABILITY CLASSIFICATION: OSHA: Combustible Class-II FLASH POINT: 108°F
 LEL: N/A DOT: Combustible

EXTINGUISHING MEDIA:
 FOAM "ALCOHOL" CO2 DRY CHEMICAL WATER FOG OTHER

UNUSUAL FIRE AND EXPLOSION HAZARDS: Keep containers tightly closed. Isolate from heat, electrical equipment, spark & open flame, closed containers may explode when exposed to extreme heat. Do not apply to hot surfaces. Paint vapors can cause a violent explosion. Supply sufficient ventilation to keep vapors below LEL level. Use explosion proof equipment.

Special Fire fighting Procedures:
 Water may be used to cool closed containers to prevent pressure build up and possible auto ignition or explosion when exposed to extreme heat. If water is used, fog nozzles are required.

SECTION V - HEALTH HAZARD DATA

EFFECTS OF OVEREXPOSURE:

Inhalation: Anesthetic irritation of the respiratory tract or acute nervous system depression characterized by headache, dizziness, staggering gait, confusion, unconsciousness or coma.

MEDICAL CONDITIONS PRONE TO AGGRAVATION BY EXPOSURE:

Asthma, Infections of the respiratory system, Bronchitis, Dermatitis.

PRIMARY ROUTE (S) OF ENTRY: DERMAL X INHALATION X INGESTION X

EMERGENCY AND FIRST AID PROCEDURES:

Eyes: Flush with large amount of water.

Skin: Wash thoroughly with soap and water.

Inhalation: Remove to respiration if not breathing.

Ingestion: Keep warm and quiet. Do not induce vomiting. Consult a physician in all cases.

SECTION VI - REACTIVITY DATA

STABILITY: UNSTABLE X STABLE

HAZARDOUS POLYMERIZATION X MAY OCCUR WILL NOT OCCUR

HAZARDOUS DECOMPOSITION PRODUCTS:

Carbon dioxide, Carbon monoxide

CONDITIONS TO AVOID:

All sources of ignition and heat

INCOMPATIBILITY (MATERIALS TO AVOID):

Excessive heat after mixing components may cause fast polymerization.

SECTION VII - TRANSPORTATION INFORMATION

U.S. DEPARTMENT OF TRANSPORTATION OR INTERNATIONAL AIR TRANSPORT ASSOCIATION OR

INTERNATIONAL MARITIME ORGANIZATION:

PROPER SHIPPING NAME:	PAINT	HAZARD CLASS:	3
UN OR ID NUMBER:	U.N. 1263	PACKING GROUP:	III

SECTION VIII - SPILL OR LEAK PROCEDURES

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED:

Remove all sources of ignition (flame, hot surfaces, and electrical static or frictional sparks). Avoid breathing vapors; ventilate area, removed with inert absorbent and non-sparking tools.

WASTE DISPOSAL METHOD:

Dispose in accordance with local, state and federal regulations. Incinerate in approved facility. Do not incinerate closed containers.

SECTION IX - SAFE HANDLING AND USE INFORMATION

RESPIRATORY PROTECTION: Self-contained breathing apparatus (SCBA) or other supplied-air respirator

VENTILATION: General ventilation is recommended. Additional local exhaust ventilation is recommended where vapors, mists or aerosol may be released

PROTECTIVE GLOVES: Wear impervious gloves, apron & splash goggles where exposure is possible. Launder contaminated clothing before reuse

EYE PROTECTIVE EQUIPMENT: Required for prolonged or repeated contact.

OTHER PROTECTIVE EQUIPMENT: Use of goggles or face shields is required to protect against splash of liquids.

HYGIENIC PRACTICES: Prevent prolonged skin contact to contaminated clothing.

SECTION X - SPECIAL PRECAUTIONS

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORING:

Keep away from heat, sparks, open flames.

OTHER PRECAUTIONS:

Drums stored in direct sunlight may build pressure.

MSDS Sheet for: MIL-DTL-24441, Formula-150 Type III Hardener for Epoxy Polyamide Primer (Comp. B)

MATERIAL SAFETY DATA SHEET

MANUFACTURER'S NAME: **FOR 24 HOURS EMERGENCY ASSISTANCE**
CALL - CHEMTREC
 Simco Coatings, Inc.
 211 Gunther Lane,
 Belle Chasse, LA 70037
 DATE OF PREPARATION: 1/2/12
 DOMESTIC NORTH AMERICA (800) 424-9300
 INTERNATIONAL, CALL (703) 527-3887
 INFORMATION TEL. NO.: (866) 957-4626

SECTION I - PRODUCT IDENTIFICATION

PRODUCT NUMBER: MIL-DTL-24441/20A (SH) HMIS RATING:
 Formula-150, Type-III
 PRODUCT NAME: Epoxy Polyamide Primer Green (Comp. A) HEALTH: 2
 PRODUCT CLASS: Epoxy Polyamide Paint FLAMMABILITY: 3
 REACTIVITY: 0
 PERSONAL PROTECTION: X

SECTION II - HAZARDOUS INGREDIENTS

INGREDIENTS	CAS #	WEIGHT PERCENT	OCCUPATIONAL EXPOSURE TLV (PPM)	LIMITS PEL (PPM)	VAPOR mm Hg @ 20° C
N-Butyl Alcohol	71-36-3	20-25	50.00	100.00	4.00

SECTION III - PHYSICAL DATA

BOILING RANGE: 244-284°F VAPOR DENSITY X HEAVIER LIGHTER THAN AIR
 EVAPORATION RATE: FASTER X SLOWER THAN ETHER %VOLATILE VOLUME: 46.00 %
 WT/GAL.: 11.50 VOLATILE ORGANIC COMPOUND (VOC) 3.00 Lb./Gallon or 360 Grm./Ltr.

SECTION IV - FIRE AND EXPLOSION HAZARD DATA

FLAMMABILITY CLASSIFICATION OSHA: Flammable FLASH POINT: 99°F
 LEL: 1.0 DOT: Flammable

EXTINGUISHING MEDIA:
 FOAM "ALCOHOL" CO2 DRY CHEMICAL WATER FOG OTHER
 FOAM

UNUSUAL FIRE AND EXPLOSION HAZARDS: Keep containers tightly closed. Isolate from heat, electrical equipment, spark & open flame, closed containers may explode when exposed to extreme heat. Do not apply to hot surfaces. Paint vapors can cause a violent explosion. Supply sufficient ventilation to keep vapors below LEL level. Use explosion proof equipment.

Special Fire fighting Procedures:

Water may be used to cool closed containers to prevent pressure build up and possible auto ignition or explosion when exposed to extreme heat. If water is used, fog nozzles are required.

SECTION V - HEALTH HAZARD DATA

EFFECTS OF OVEREXPOSURE:

Inhalation: Anesthetic irritation of the respiratory tract or acute nervous system depression characterized by headache, dizziness, staggering gait, confusion, unconsciousness or coma.

MEDICAL CONDITIONS PRONE TO AGGRAVATION BY EXPOSURE:

Asthma, Infections of the respiratory system, Bronchitis, Dermatitis.

PRIMARY ROUTE (S) OF ENTRY: DERMAL X INHALATION X INGESTION X

EMERGENCY AND FIRST AID PROCEDURES:

Eyes: Flush with large amount of water.

Skin: Wash thoroughly with soap and water.

Inhalation: Remove to respiration if not breathing.

Ingestion: Keep warm and quiet. Do not induce vomiting. Consult a physician in all cases.

SECTION VI - REACTIVITY DATA

STABILITY: UNSTABLE X STABLE

HAZARDOUS POLYMERIZATION X MAY OCCUR WILL NOT OCCUR

HAZARDOUS DECOMPOSITION PRODUCTS:

Carbon dioxide, Carbon monoxide

CONDITIONS TO AVOID:

All sources of ignition and heat

INCOMPATIBILITY (MATERIALS TO AVOID):

Excessive heat after mixing components may cause fast polymerization.

SECTION VII - TRANSPORTATION INFORMATION

U.S. DEPARTMENT OF TRANSPORTATION OR INTERNATIONAL AIR TRANSPORT ASSOCIATION OR

INTERNATIONAL MARITIME ORGANIZATION:

PROPER SHIPPING NAME:	PAINT	HAZARD CLASS:	3
UN OR ID NUMBER:	U.N. 1263	PACKING GROUP:	III

SECTION VIII - SPILL OR LEAK PROCEDURES

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED:

Remove all sources of ignition (flame, hot surfaces, and electrical static or frictional sparks). Avoid breathing vapors; ventilate area, removed with inert absorbent and non-sparking tools.

WASTE DISPOSAL METHOD:

Dispose in accordance with local, state and federal regulations. Incinerate in approved facility. Do not incinerate closed containers.

SECTION IX - SAFE HANDLING AND USE INFORMATION

RESPIRATORY PROTECTION: Self-contained breathing apparatus (SCBA) or other supplied-air respirator

VENTILATION: General ventilation is recommended. Additional local exhaust ventilation is recommended where vapors, mists or aerosol may be released

PROTECTIVE GLOVES: Wear impervious gloves, apron & splash goggles where exposure is possible. Launder contaminated clothing before reuse

EYE PROTECTIVE EQUIPMENT: Required for prolonged or repeated contact.

OTHER PROTECTIVE EQUIPMENT: Use of goggles or face shields is required to protect against splash of liquids.

HYGIENIC PRACTICES: Prevent prolonged skin contact to contaminated clothing.

SECTION X - SPECIAL PRECAUTIONS

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORING:

Keep away from heat, sparks, open flames.

OTHER PRECAUTIONS:

Drums stored in direct sunlight may build pressure.

MSDS Sheet for: MIL-DTL-24441, Formula-150 Type III Epoxy Polyamide Primer Green (Comp. A)

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
 United States Patent and Trademark Office
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 Alexandria, Virginia 22313-1450
 www.uspto.gov

APPLICATION NUMBER	FILING or 371(c) DATE	GRP PART UNIT	FIL FEE REC'D	ATTY DOCKET NO	TOT CLAIMS	IND CLAIMS
61/842,227	07/02/2013		130	506639706		

CONFIRMATION NO. 3777

FILING RECEIPT

Date Mailed: 07/10/2013

Robert Walde
 5254 Armour Ct.
 Haymarket, VA 20169

Receipt is acknowledged of this provisional patent application. It will not be examined for patentability and will become abandoned not later than twelve months after its filing date. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. **If an error is noted on this Filing Receipt, please submit a written request for a Filing Receipt Correction. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections**

Inventor(s)

Robert Walde, Haymarket, VA;
 Timothy Alan Knell, McMurray, PA;

Applicant(s)

Robert Walde, Haymarket, VA;
 Timothy Alan Knell, McMurray, PA;

Power of Attorney: None

If Required, Foreign Filing License Granted: 07/09/2013

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 61/842,227**

Projected Publication Date: None, application is not eligible for pre-grant publication

Non-Publication Request: No

Early Publication Request: No

** SMALL ENTITY **

Title

CORROSION INHIBITING PAINT COATING

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications: No

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent

SURTREAT EPOXY PLUS VCI
MIL-DTL-24441/20
FORMULA 150, TYPE III
PART A MODIFIED
SURTREAT TYPE 12 VCI ADDED
VAPOR PHASE CORROSION INHIBITOR (VCI)
A + B DRY FILM SOLIDS 2.5 WT% VCI

SUPPLIED BY
SURTREAT HOLDING, LLC
437 GRANT ST. Suite 1210
PITTSBURGH PA 15219
412-281-1202
surtreat_tony@yahoo.com
www.surtreat.info

SIMCO

We've got you covered

PERFORMANCE COATINGS

EPOXY POLYAMIDE PRIMER FORMULA-150, TYPE-III

MIL-DTL-24441/20

GREEN

(COMPONENT-A)

CONTENT: NET ONE U.S. GALLON
MIX WITH 1.00 GALLON OF HARDENER
(COMPONENT-B) FORMULA-150, TYPE-III
BEFORE USE

BATCH NO.: 7584-I-D13

D.O.M.: 09/13

D.O.E.: 09/14

INDS. & MARINE PAINTS

WARNING - KEEP OUT OF REACH OF CHILDREN

Flammable. Vapor and/or spray mist can be harmful, irritating to skin, mucous membranes, eyes and respiratory system. Excessive inhalation can cause headache, nausea, dizziness or asphyxiation. Can be harmful if inhaled, swallowed or absorbed through skin. Kidney and liver damage may occur.

HAZARDS - Keep away from heat, sparks, arc and open flame. Avoid breathing vapor, spray mist contact with eyes and skin. Use only with adequate ventilation during mixing, application and drying. Use face protection, gloves and full protective clothing to prevent contact. Wear appropriate, self-contained respiratory equipment when handling. Use only with SIMCO recommended thinners and cleaners.

FIRST AID - Overexposure to vapor - provide fresh air. Give artificial respiration or oxygen if breathing is labored. For skin contact, wash thoroughly with soap and water. For eyes, flush immediately with plenty of water for at least 15 minutes and get medical attention. If swallowed, DO NOT induce vomiting - call a physician. Launder contaminated clothing before reuse.

FIRE-Blanket flames with dry chemical, carbon dioxide, or foam. Wear self-contained breathing apparatus. **SPILLAGE**-Extinguish all sources of ignition. Use absorbent material to clean up spilled materials. **STORAGE AND DISPOSAL**-Store in cool well ventilated area. Keep containers closed and upright when not in use to prevent leakage. Dispose of in separate, closed metal container in accordance with applicable regulations. **IMPORTANT**-Improper use and handling of this product can be hazardous to health and cause fire or explosion. Consult Code of Federal Regulations Title 29, Labor, parts 1910 and 1916 concerning occupational safety and health standards and regulations, as well as any other applicable federal, state and local regulations on safe practices in coating operations. Necessary safety equipment must be used and ventilation requirements carefully observed, especially in confined or enclosed spaces. **WARRANTY**-We guarantee our products to conform to SIMCO quality control standards. We assume no responsibility to its handling, use, storage, the results claimed or any injury or damage resulting from its use.

MANUFACTURED BY SIMCO COATINGS INC.

211 GUNTHER LANE, BELLE CHASSE, LA 70037, USA

E-mail: sales@simcocoatings.com Web: www.simcocoatings.com

SIMCO

We've got you covered

WARNING - KEEP OUT OF REACH OF CHILDREN

Flammable. Vapor and/or spray mist can be harmful, irritating to skin, mucous membranes, eyes and respiratory system. Excessive inhalation can cause headache, nausea, dizziness or asphyxiation. Can be harmful if inhaled, swallowed or absorbed through skin. Kidney and liver damage may occur.

HAZARDS - Keep away from heat, sparks, arcs and open flames. Avoid breathing vapor, spray mist or contact with eyes and skin. Use only with adequate ventilation during mixing, application and drying. Use face protection, gloves and full protective clothing to prevent contact. Wear appropriate and contained respiratory equipment when handling. Use only with SIMCO recommended thinners and cleaners.

FIRST AID - Overexposure to vapor - provide fresh air. Give artificial respiration or oxygen if breathing is labored. For skin contact, wash thoroughly with soap and water. For eyes, flush immediately with plenty of water for at least 15 minutes and get medical attention. If swallowed, DO NOT induce vomiting - call a physician. Launder contaminated clothing before reuse.

PERFORMANCE COATINGS

HARDENER FOR EPOXY POLYAMIDE PRIMER

FORMULA-150, TYPE-III

MIL-DTL-24441/20

(COMPONENT-B)

BATCH NO.: 7585-I-D13

D.O.M.: 09/13

D.O.E.: 09/14

CONTENT: NET ONE U.S. GALLON

MIX WITH 1.00 GALLON OF EPOXY

POLYAMIDE PRIMER (COMPONENT-A)

FORMULA-150, TYPE-III BEFORE USE

INDS. & MARINE PAINTS

FIRE - Ignites flames with dry chemical, carbon dioxide or foam. Wear self-contained breathing apparatus.

SPILLAGE - Extinguish with foam. Use absorbent clothing and gloves.

STORAGE AND DISPOSAL - Store in cool well ventilated area. Keep containers closed and upright when not in use to prevent leakage. Dispose of in separate closed metal container in accordance with applicable regulations.

IMPORTANT - Improper use and handling of this product can be hazardous to health and cause fire or explosion. Consult Code of Federal Regulations Title 29 Labor, parts 1910 and 1916 concerning occupational safety and health standards and regulations, as well as any other applicable federal, state and local regulations on safe practices in coating operations. Necessary safety equipment must be used and ventilation requirements carefully observed, especially in confined or enclosed spaces.

WARRANTY - We guarantee our products to conform to SIMCO quality control standards. We assume no responsibility to its handling, use, storage, the results claimed or any injury or damage resulting from its use.

MANUFACTURED BY SIMCO COATINGS INC.

211 GUNTHER LANE, BELLE CHASSE, LA 70037, USA

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Simco Coatings Inc.

Manufacturer of Military Spec.,
Corps of Engrs. Spec, Industrial, &
Marine Coatings

Product Information

MIL-PRF-85285
ALIPHATIC POLYURETHANE COATING
FOR AIRCRAFT AND SUPPORT EQUIPEMENT

DESCRIPTION: A two part, VOC compliant, polyester/aliphatic polyurethane coating is intended for use on aircraft weapons systems and other applications.

CONFORMANCE: Conforms to federal specification MIL-PRF-85285, Type II

TECHNICAL DATA

COLORS & FINISH:	Fed-std-595, Colors in gloss, semi- gloss and camouflage finish
GENERIC TYPE:	Polyester/Urethane
MIXING RATIO:	2:1 by Volume
SOLIDS BY WEIGHT %:	65 ± 1
SOLIDS BY VOLUME %:	51 ± 1
VOLATILE ORGANIC COMPOUNDS (VOC) :	3.5 Lbs. / Gal. or 420 Grms./Ltr.
RECOMMENDED DRY FILM THICKNESS:	1.5 – 2.0 Mils/Coat
THEORETICAL SPREADING RATE:	225 sq. ft. /gal. @ 2.0 Mil DFT
FLASH POINT:	30 °F
DRYING TIME @ 75°F:	
(A) SET TO TOUCH, HRS. MAX:	6
(B) DRY HARD, HRS. MAX:	12
POT LIFE @ 25°C/77°F HRS. MIN:	5
RECOMMENDED PRIMERS:	MIL-PRF-23377 or MIL-P-24441
THINNER:	MIL-T-81772, Type-I Thinner for Aircraft Coating

Simco Coatings Inc.
211 Gunther Ln., Belle Chasse, Louisiana 70037 U.S.A.
Tel: (504) 393-9455 Fax: (504) 433-1406 Toll Free: 1-866-95SIMCO
e-mail: sales@simcocoatings.com web: www.simcocoatings.com

Simco Coatings Inc.

Manufacturer of Military Spec.,
Corps of Engrs. Spec, Industrial, &
Marine Coatings

MIL-PRF-85285
ALIPHATIC POLYURETHANE COATING
FOR AIRCRAFT AND SUPPORT EQUIPEMENT

MIXING:

This product is supplied in 3 Gallon kits, which consists of 2 Gallons of the Paint (Short Filled in 3 ½ Gallon containers) and 1 Gallon of the Hardener (Curing Agent) packaged separately. Mix both the components using a hand held paddle to a homogenous product.

APPLICATION:

The coating can be applied by conventional, airless, HVLP or electrostatic spray application. When spray is applied at 15.6 to 32.2 °C (60-90 °F) and a relative humidity of 20-80 percent, the coating material shall yield a smooth uniform film of dry film thickness of about 2.0 mils.

SAFETY PRECAUTIONS:

- (A) Use normal precautions such as gloves and facemasks.
- (B) Adequate ventilation must be maintained.
- (C) Explosion proof lights and electrical equipment.
- (D) Non-sparking shoes and tools for workers in area.
- (E) This product contains flammable materials. Forbid all flames, smoking and welding in work area.
- (F) Avoid breathing of vapor, contact with skin and eyes. If product comes in contact with skin or eyes, wash thoroughly with water and obtain immediate medical attention.

NON-WARRANTY:

The technical data listed herein has been compiled for your convenience and guidance, and is based upon our experience and knowledge. However, since we have no control over the use of this information or this product, no warranty, expressed or implied, is intended or given. Simco Coatings, Inc. assumes no responsibility whatsoever for coverage, performance or any other damages, including injuries resulting from us of this information or of products recommended herein.

FOR INDUSTRIAL USE ONLY

2/16/12

Simco Coatings Inc.
211 Gunther Ln., Belle Chasse, Louisiana 70037 U.S.A.
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e-mail: sales@simcocoatings.com web: www.simcocoatings.com

MATERIAL SAFETY DATA SHEET

MANUFACTURER'S NAME: **FOR 24 HOURS EMERGENCY ASSISTANCE
CALL - CHEMTREC**

Simco Coatings, Inc.
211 Gunther Lane,
Belle Chasse, LA 70037

DOMESTIC NORTH AMERICA (800) 424-9300
INTERNATIONAL, CALL (703) 527-3887

DATE OF PREPARATION:

1/12/12

INFORMATION TEL. NO.: (866) 957-4626

SECTION I - PRODUCT IDENTIFICATION

PRODUCT NUMBER: MIL-PRF-85285
PRODUCT NAME: Aliphatic Polyurethane Coating Resin
Component-A (Part-A) White # 17925, Type -II
PRODUCT CLASS: Polyester Polyol

HMIS RATING:
HEALTH: 2
FLAMMABILITY: 3
REACTIVITY: 0
PERSONAL PROTECTION: X

SECTION II - HAZARDOUS INGREDIENTS

INGREDIENT	CAS #	WEIGHT PERCENT	OCCUPATIONAL EXPOSURE TLV (PPM)	LIMITS PEL (PPM)	VAPOR mm Hg @ 20°C
N-Butyl Acetate	123-86-4	1-2	150.00	150.00	8.40
Propylene Glycol	108-65-6	5-10	100.00	150.00	3.70
Monomethyl Ether Acetate					
Methyl N-Amyl Ketone	110-43-0	15-20	50.00	100.00	2.80
Methyl Ethyl Ketone	78-93-3	<1.0	200.00	200.00	2.50
Xylene	1330-20-7	<1.0	100.00	100.00	5-10
Diisobutyl Ketone	108-83-6	2-3	25.00	50.00	2.30

SECTION III - PHYSICAL DATA

BOILING RANGE: 150-325 °F VAPOR DENSITY: x HEAVIER: LIGHTER THAN AIR:
EVAPORATION RATE: FASTER X SLOWER THAN ETHER %VOLATILE VOLUME: 41.00
WT/GAL.: 12.7 ± 0.2 lbs. VOLATILE ORGANIC COMPOUND (VOC) 2.8 LBS./GAL. OR 336 GRMS./LTR.

SECTION IV - FIRE AND EXPLOSION HAZARD DATA

FLAMMABILITY CLASSIFICATION: OSHA: FLAMMABLE LIQUID FLASH POINT: 30°F
LEL: 1.0 DOT: FLAMMABLE LIQUID
EXTINGUISHING MEDIA: FOAM CARBON DIOXIDE DRY CHEMICAL FOG
FIRE AND EXPLOSION HAZARDS: This material may polymerize (react) when its container is exposed to heat (as during a fire). This Polymerization increases pressure inside a closed container and may result in the violent rupture of the container
HAZARDOUS COMBUSTION PRODUCTS: The by-products expected in incomplete pyrolysis or combustion of epoxy resins are mainly phenolics, carbon monoxide and water.

SECTION V - HEALTH HAZARD DATA

EFFECTS OF OVEREXPOSURE:
Inhalation: Anesthetic irritation of the respiratory tract or acute nervous system depression characterized by headache, dizziness, staggering gait, confusion, unconsciousness or coma.
MEDICAL CONDITIONS PRONE TO AGGRAVATION BY EXPOSURE:
Asthma, Infections of the respiratory system, Bronchitis, Dermatitis.
PRIMARY ROUTE (S) OF ENTRY: DERMAL X INHALATION X INGESTION X
EMERGENCY AND FIRST AID PROCEDURES: Eyes: Flush with large amount of water.
Skin: Wash thoroughly with soap and water.
Inhalation: Remove to respiration if not breathing Ingestion: Keep warm and quiet. Do not induce vomiting. Consult a physician in all cases.

SECTION VI - REACTIVITY DATA

STABILITY: UNSTABLE X STABLE
HAZARDOUS POLYMERIZATION X MAY OCCUR WILL NOT OCCUR
HAZARDOUS DECOMPOSITION PRODUCTS:
Carbon dioxide, Carbon monoxide
CONDITIONS TO AVOID:
All sources of ignition and heat
INCOMPATIBILITY (MATERIALS TO AVOID):
Excessive heat after mixing components may cause fast polymerization.

SECTION VII - TRANSPORTATION INFORMATION

U.S. DEPARTMENT OF TRANSPORTATION OR INTERNATIONAL AIR TRANSPORT ASSOCIATION OR
INTERNATIONAL MARITIME ORGANIZATION:
PROPER SHIPPING NAME: PAINT HAZARD CLASS: 3
UN OR ID NUMBER: U.N. 1263 PACKING GROUP: II

SECTION VIII - SPILL OR LEAK PROCEDURES

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED:
Remove all sources of ignition (flame, hot surfaces, and electrical static or frictional sparks). Avoid breathing vapors; ventilate area, removed with inert absorbent and non-sparking tools.
WASTE DISPOSAL METHOD:
Dispose in accordance with local, state and federal regulations. Incinerate in approved facility. Do not incinerate closed containers.

SECTION IX - SAFE HANDLING AND USE INFORMATION

RESPIRATORY PROTECTION: Self-contained breathing apparatus (SCBA) or other supplied-air respirator
VENTILATION: General ventilation is recommended. Additional local exhaust ventilation is recommended where vapors, mists or aerosol may be released
PROTECTIVE GLOVES: Wear impervious gloves, apron & splash goggles where exposure is possible. Launder contaminated clothing before reuse
EYE PROTECTIVE EQUIPMENT: Required for prolonged or repeated contact.
OTHER PROTECTIVE EQUIPMENT: Use of goggles or face shields is required to protect against splash of liquids.
HYGIENIC PRACTICES: Prevent prolonged skin contact to contaminated clothing.

SECTION X - SPECIAL PRECAUTIONS

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORING:
Keep away from heat, sparks, open flames.
OTHER PRECAUTIONS:
Drums stored in direct sunlight may build pressure

MATERIAL SAFETY DATA SHEET

MANUFACTURER'S NAME: **FOR 24 HOURS EMERGENCY ASSISTANCE**
CALL - CHEMTREC

Simco Coatings, Inc.
 211 Gunther Lane,
 Belle Chasse, LA 70037

DATE OF PREPARATION: 1/12/12

DOMESTIC NORTH AMERICA (800) 424-9300
 INTERNATIONAL, CALL (703) 527-3887

INFORMATION TEL. NO.: (866) 957-4626

SECTION I - PRODUCT IDENTIFICATION

PRODUCT NUMBER: MIL-PRF-85285, Type-II
 PRODUCT NAME: Hardener for Polyurethane Coating (Part-B)
 PRODUCT CLASS: Aliphatic Polyisocyanate

HMIS RATING:
 HEALTH: 2
 FLAMMABILITY: 3
 REACTIVITY: 1
 PERSONAL PROTECTION: X

SECTION II - HAZARDOUS INGREDIENTS

INGREDIENT	CAS #	WEIGHT PERCENT	OCCUPATIONAL EXPOSURE TLV (PPM)	LIMITS PEL (PPM)	VAPOR mm Hg @ 20°C
Polymeric Hexamethylene Diisocyanate	28182-81-2	65-70	1.00 mg/m3	0.5mg/m3	9.3x10-6
Methyl N-Amyl Ketone	110-43-0	25-30	50.00	100.00	2.8
Methyl Ethyl Ketone	78-93-3	4-5	200.00	200.00	2.5

SECTION III - PHYSICAL DATA

BOILING RANGE: 150-280 °F VAPOR DENSITY: x HEAVIER: LIGHTER THAN AIR:
 EVAPORATION RATE: FASTER X SLOWER THAN ETHER %VOLATILE VOLUME: 40.00
 WT/GAL.: 8.40 VOLATILE ORGANIC COMPOUND (VOC) 2.65 LBS./GAL. OR 318 GRMS./LTR.

SECTION IV - FIRE AND EXPLOSION HAZARD DATA

FLAMMABILITY CLASSIFICATION: OSHA: FLAMMABLE LIQUID FLASH POINT: 30 °F
 LEL: 1.0 DOT: FLAMMABLE LIQUID
 EXTINGUISHING MEDIA: FOAM CARBON DIOXIDE DRY CHEMICAL FOG
 FIRE AND EXPLOSION HAZARDS: This material may polymerize (react) when its container is exposed to heat (as during a fire). This Polymerization increases pressure inside a closed container and may result in the violent rupture of the container
 HAZARDOUS COMBUSTION PRODUCTS: The by-products expected in incomplete pyrolysis or combustion of epoxy resins are mainly phenolics, carbon monoxide and water.

SECTION V - HEALTH HAZARD DATA

EFFECTS OF OVEREXPOSURE:
 Inhalation: Anesthetic irritation of the respiratory tract or acute nervous system depression characterized by headache, dizziness, staggering gait, confusion, unconsciousness or coma.
 MEDICAL CONDITIONS PRONE TO AGGRAVATION BY EXPOSURE:
 Asthma, Infections of the respiratory system, Bronchitis, Dermatitis.
 PRIMARY ROUTE (S) OF ENTRY: DERMAL X INHALATION X INGESTION X
 EMERGENCY AND FIRST AID PROCEDURES:
 Eyes: Flush with large amount of water.
 Skin: Wash thoroughly with soap and water.
 Inhalation: Remove to respiration if not breathing.
 Ingestion: Keep warm and quiet. Do not induce vomiting. Consult a physician in all cases.

SECTION VI - REACTIVITY DATA

STABILITY: UNSTABLE X STABLE
HAZARDOUS POLYMERIZATION X MAY OCCUR WILL NOT OCCUR
HAZARDOUS DECOMPOSITION PRODUCTS:
Carbon dioxide, Carbon monoxide
CONDITIONS TO AVOID:
All sources of ignition and heat
INCOMPATIBILITY (MATERIALS TO AVOID):
Excessive heat after mixing components may cause fast polymerization.

SECTION VII - TRANSPORTATION INFORMATION

U.S. DEPARTMENT OF TRANSPORTATION OR INTERNATIONAL AIR TRANSPORT ASSOCIATION OR
INTERNATIONAL MARITIME ORGANIZATION:
PROPER SHIPPING NAME: PAINT HAZARD CLASS: 3
UN OR ID NUMBER: U.N. 1263 PACKING GROUP: II

SECTION VIII - SPILL OR LEAK PROCEDURES

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED:
Remove all sources of ignition (flame, hot surfaces, and electrical static or frictional sparks). Avoid breathing vapors; ventilate area, removed with inert absorbent and non-sparking tools.
WASTE DISPOSAL METHOD:
Dispose in accordance with local, state and federal regulations. Incinerate in approved facility. Do not incinerate closed containers.

SECTION IX - SAFE HANDLING AND USE INFORMATION

RESPIRATORY PROTECTION: Self-contained breathing apparatus (SCBA) or other supplied-air respirator
VENTILATION: General ventilation is recommended. Additional local exhaust ventilation is recommended where vapors, mists or aerosol may be released
PROTECTIVE GLOVES: Wear impervious gloves, apron & splash goggles where exposure is possible. Launder contaminated clothing before reuse
EYE PROTECTIVE EQUIPMENT: Required for prolonged or repeated contact.
OTHER PROTECTIVE EQUIPMENT: Use of goggles or face shields is required to protect against splash of liquids.
HYGIENIC PRACTICES: Prevent prolonged skin contact to contaminated clothing.

SECTION X - SPECIAL PRECAUTIONS

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORING:
Keep away from heat, sparks, and open flames.
OTHER PRECAUTIONS:
Drums stored in direct sunlight may build pressure

MSDS Sheet for: MIL-PRF-85285 HARDENER FOR POLYURETHANE COATING (Part-B) Type-II

Appendix B: Corrosion Potential Assessment for Corpus Christi Army Depot

Classification method

A corrosion severity classification for this site at Corpus Christi Army Depot (CCAD) was developed to evaluate coatings used in this project. This was accomplished through placing a portable weather station at the site and collecting weather data for one year, placing an atmospheric corrosion test rack at the site, and conducting visual inspections during semi-annual site visits.

Monitoring

Weather station

A weather station (similar to Figure B1) was installed to measure and record environmental characteristics throughout the 12-month exposure period. The station measured temperature, relative humidity, wind speed and direction, solar radiation, dew point, and rainfall. The weather station was powered by a solar panel and a rechargeable battery. A data logger was used to store the measurements which were recorded every 12 hours by the rain gauge and every 30 minutes by all other sensors. Data were downloaded manually to a laptop coming during on-site inspections. The data logger and each sensor were powered by a rechargeable battery connected to a solar panel. The data logger has a storage capacity to continue storing data at 30-minute intervals for approximately 2.5 years. Upon reaching full capacity, the data logger will truncate the oldest data point to create room for new incoming data.

Atmospheric coupon rack

An atmospheric coupon rack to determine the relative corrosivity of the site was attached to an exposure rack at the site. The coupon rack was similar to the one in Figure B2, except there were only two stacks of coupons used. The corrosion coupons in each stack included silver, copper, 1010 steel, and three aluminum alloys: 2024 T3, 6061 T6 and 7075 T6 and measured 1 inch wide by 4 in. long by 1/16 in. thick. These coupons were collected after 6 and 12 months of exposure. The mass of each coupon was recorded before being exposed to the test environment. The silver coupon

was tested for chloride deposition in accordance with ASTM B825. The remaining coupons were analyzed for mass loss in accordance with ASTM G1.

Figure B1. Weather station.

Figure B2. Atmospheric corrosion test rack.

Assessments, weather, corrosion coupon rack

Weather data was analyzed using response functions from the ISO 9223:2012 *Corrosion of Metal and Alloys – Corrosivity of Atmospheres – Classification, Determination and Estimation* (see Figure B3). Sulfur dioxide (SO₂) measurements were not collected; however due to the location of CCAD, it was assumed the deposition of SO₂ would be equal to zero milligrams per square meter per day. The amount of chloride (Cl) deposition (see Table B7) was calculated using ASTM B825 *Coulometric Reduction of Surface Films on Metallic Test* of the silver coupon. The equations used are reproduced as Figure B3. Corrosion classifications per ISO 9223:2012 are listed in Table B1. A further description of typical atmospheric environments related to the estimation of corrosivity categories is given in Table B2.

Figure B3. Response equations for four standard metals (ISO 9223:2012).

Equation (1) for carbon steel:

$$r_{\text{corr}} = 1,77 \cdot P_d^{0,52} \cdot \exp(0,020 \cdot \text{RH} + f_{\text{St}}) + 0,102 \cdot S_d^{0,62} \cdot \exp(0,033 \cdot \text{RH} + 0,040 \cdot T) \quad (1)$$

$$f_{\text{St}} = 0,150 \cdot (T - 10) \text{ when } T \leq 10 \text{ }^\circ\text{C}; \text{ otherwise } -0,054 \cdot (T - 10)$$

$$N = 128, R^2 = 0,85$$

Equation (2) for zinc:

$$r_{\text{corr}} = 0,0129 \cdot P_d^{0,44} \cdot \exp(0,046 \cdot \text{RH} + f_{\text{Zn}}) + 0,0175 \cdot S_d^{0,57} \cdot \exp(0,008 \cdot \text{RH} + 0,085 \cdot T) \quad (2)$$

$$f_{\text{Zn}} = 0,038 \cdot (T - 10) \text{ when } T \leq 10 \text{ }^\circ\text{C}; \text{ otherwise, } -0,071 \cdot (T - 10)$$

$$N = 114, R^2 = 0,78$$

Equation (3) for copper:

$$r_{\text{corr}} = 0,0053 \cdot P_d^{0,26} \cdot \exp(0,059 \cdot \text{RH} + f_{\text{Cu}}) + 0,01025 \cdot S_d^{0,27} \cdot \exp(0,036 \cdot \text{RH} + 0,049 \cdot T) \quad (3)$$

$$f_{\text{Cu}} = 0,126 \cdot (T - 10) \text{ when } T \leq 10 \text{ }^\circ\text{C}; \text{ otherwise, } -0,080 \cdot (T - 10)$$

$$N = 121, R^2 = 0,88$$

Equation (4) for aluminium:

$$r_{\text{corr}} = 0,0042 \cdot P_d^{0,73} \cdot \exp(0,025 \cdot \text{RH} + f_{\text{Al}}) + 0,0018 \cdot S_d^{0,60} \cdot \exp(0,020 \cdot \text{RH} + 0,094 \cdot T) \quad (4)$$

$$f_{\text{Al}} = 0,009 \cdot (T - 10) \text{ when } T \leq 10 \text{ }^\circ\text{C}; \text{ otherwise } -0,043 \cdot (T - 10)$$

$$N = 113, R^2 = 0,65$$

where

r_{corr}	is first-year corrosion rate of metal, expressed in micrometres per year ($\mu\text{m/a}$);
T	is the annual average temperature, expressed in degrees Celsius ($^\circ\text{C}$);
RH	is the annual average relative humidity, expressed as a percentage (%);
P_d	is the annual average SO_2 deposition, expressed in milligrams per square metre per day [$\text{mg}/(\text{m}^2 \cdot \text{d})$];
S_d	is the annual average Cl^- deposition, expressed in milligrams per square metre per day [$\text{mg}/(\text{m}^2 \cdot \text{d})$].

Table B1. Corrosion rate, r_{corr} for the first year of exposure for the different corrosivity categories (ISO 9223:2012).

Corrosivity category	Corrosion rates of metals				
	Unit	Carbon steel	Zinc	Copper	Aluminium
C1	g/(m ² ·a)	$r_{\text{corr}} \leq 10$	$r_{\text{corr}} \leq 0,7$	$r_{\text{corr}} \leq 0,9$	negligible
	µm/a	$r_{\text{corr}} \leq 1,3$	$r_{\text{corr}} \leq 0,1$	$r_{\text{corr}} \leq 0,1$	—
C2	g/(m ² ·a)	$10 < r_{\text{corr}} \leq 200$	$0,7 < r_{\text{corr}} \leq 5$	$0,9 < r_{\text{corr}} \leq 5$	$r_{\text{corr}} \leq 0,6$
	µm/a	$1,3 < r_{\text{corr}} \leq 25$	$0,1 < r_{\text{corr}} \leq 0,7$	$0,1 < r_{\text{corr}} \leq 0,6$	—
C3	g/(m ² ·a)	$200 < r_{\text{corr}} \leq 400$	$5 < r_{\text{corr}} \leq 15$	$5 < r_{\text{corr}} \leq 12$	$0,6 < r_{\text{corr}} \leq 2$
	µm/a	$25 < r_{\text{corr}} \leq 50$	$0,7 < r_{\text{corr}} \leq 2,1$	$0,6 < r_{\text{corr}} \leq 1,3$	—
C4	g/(m ² ·a)	$400 < r_{\text{corr}} \leq 650$	$15 < r_{\text{corr}} \leq 30$	$12 < r_{\text{corr}} \leq 25$	$2 < r_{\text{corr}} \leq 5$
	µm/a	$50 < r_{\text{corr}} \leq 80$	$2,1 < r_{\text{corr}} \leq 4,2$	$1,3 < r_{\text{corr}} \leq 2,8$	—
C5	g/(m ² ·a)	$650 < r_{\text{corr}} \leq 1\,500$	$30 < r_{\text{corr}} \leq 60$	$25 < r_{\text{corr}} \leq 50$	$5 < r_{\text{corr}} \leq 10$
	µm/a	$80 < r_{\text{corr}} \leq 200$	$4,2 < r_{\text{corr}} \leq 8,4$	$2,8 < r_{\text{corr}} \leq 5,6$	—
CX	g/(m ² ·a)	$1\,500 < r_{\text{corr}} \leq 5\,500$	$60 < r_{\text{corr}} \leq 180$	$50 < r_{\text{corr}} \leq 90$	$r_{\text{corr}} > 10$
	µm/a	$200 < r_{\text{corr}} \leq 700$	$8,4 < r_{\text{corr}} \leq 25$	$5,6 < r_{\text{corr}} \leq 10$	—

NOTE 1 The classification criterion is based on the methods of determination of corrosion rates of standard specimens for the evaluation of corrosivity (see ISO 9226).

NOTE 2 The corrosion rates, expressed in grams per square metre per year [g/(m²·a)], are recalculated in micrometres per year (µm/a) and rounded.

NOTE 3 The standard metallic materials are characterized in ISO 9226.

NOTE 4 Aluminium experiences uniform and localized corrosion. The corrosion rates shown in this table are calculated as uniform corrosion. Maximum pit depth or number of pits can be a better indicator of potential damage. It depends on the final application. Uniform corrosion and localized corrosion cannot be evaluated after the first year of exposure due to passivation effects and decreasing corrosion rates.

NOTE 5 Corrosion rates exceeding the upper limits in category C5 are considered extreme. Corrosivity category CX refers to specific marine and marine/industrial environments (see Annex C).

Table B2. Description of typical atmospheric environments related to the estimation of corrosivity categories (ISO 9223:2012).

Corrosivity category ^a	Corrosivity	Typical environments — Examples ^b	
		Indoor	Outdoor
C1	Very low	Heated spaces with low relative humidity and insignificant pollution, e.g. offices, schools, museums	Dry or cold zone, atmospheric environment with very low pollution and time of wetness, e.g. certain deserts, Central Arctic/Antarctica
C2	Low	Unheated spaces with varying temperature and relative humidity. Low frequency of condensation and low pollution, e.g. storage, sport halls	Temperate zone, atmospheric environment with low pollution ($\text{SO}_2 < 5 \mu\text{g}/\text{m}^3$), e.g. rural areas, small towns Dry or cold zone, atmospheric environment with short time of wetness, e.g. deserts, subarctic areas
C3	Medium	Spaces with moderate frequency of condensation and moderate pollution from production process, e.g. food-processing plants, laundries, breweries, dairies	Temperate zone, atmospheric environment with medium pollution (SO_2 : $5 \mu\text{g}/\text{m}^3$ to $30 \mu\text{g}/\text{m}^3$) or some effect of chlorides, e.g. urban areas, coastal areas with low deposition of chlorides Subtropical and tropical zone, atmosphere with low pollution
C4	High	Spaces with high frequency of condensation and high pollution from production process, e.g. industrial processing plants, swimming pools	Temperate zone, atmospheric environment with high pollution (SO_2 : $30 \mu\text{g}/\text{m}^3$ to $90 \mu\text{g}/\text{m}^3$) or substantial effect of chlorides, e.g. polluted urban areas, industrial areas, coastal areas without spray of salt water or, exposure to strong effect of de-icing salts Subtropical and tropical zone, atmosphere with medium pollution
C5	Very high	Spaces with very high frequency of condensation and/or with high pollution from production process, e.g. mines, caverns for industrial purposes, unventilated sheds in subtropical and tropical zones	Temperate and subtropical zone, atmospheric environment with very high pollution (SO_2 : $90 \mu\text{g}/\text{m}^3$ to $250 \mu\text{g}/\text{m}^3$) and/or significant effect of chlorides, e.g. industrial areas, coastal areas, sheltered positions on coastline

A summary of the weather data collected from October 2015–October 2016 is listed in Table B3. The results from the response equation calculations in Figure B3 are listed in Table B4. This equation also uses the chloride deposition rate determined in the assessment of the atmospheric corrosion coupons.

Table B3. Summary of weather data collected October 2015–October 2016.

	Wind Direction, $\emptyset$	Wind Speed, mph	Speed, mph	Temp, $^{\circ}\text{F}$	RH, %	Radiation, W/m^2	DewPt, $^{\circ}\text{F}$	Rain, in
Average	244.5691213	9.079089179	14.0740209	74.70637995	62.8633029	341.3688628	48.68814	0.04561255
Standard Deviation	102.5062393	4.666945834	6.37096633	10.81356208	33.8561455	432.8678342	33.6743	0.35143651
Maximum	355.2	40	61.96	94.944	100	1276.9	87.4	7.002
Minimum	0	0	0	39.078	1	0.6	-33.2	0
Mode	355.2	9.57	12.95	83.467	1	0.6	72.5	0

Table B4. Atmospheric corrosion severity classification from weather data and ISO 9223:2012 response equation calculations.

	Steel	Copper	Aluminum	Zinc
Rcorr [$\mu\text{m/a}$]	167.0856	2.1204	4.0829	11.8198
Classification	C5 (Very High)	C4 (High)	-	CX (Extreme)

Coupon rack data

The atmospheric corrosion coupon rack placed at the site had coupons removed at 6 and 12 months. These coupons were sent to a certified lab (Applied Technical Services, Inc. [ATS]) and mass loss was measured per ASTM G1-03 on the AL 6061 T6, AL 2024 T3, AL 7075 T6, C 1010, and CDA 101. The silver test coupon had Coulometric Reduction of Surface Films done per ASTM B 825-13. A summary of the test results and classification according to the categories listed in ISO 9223:2012 (Table 1) is listed in Tables B5 and B6. The annual chloride deposition is listed in Table B7. This deposition value is used in the ISO 9223:2012 calculations.

Table B5. Summary of results from the 6-month exposure ASTM G1 mass loss test and corrosion classification per ISO 9223:2012.

	1010 Steel	CDA101	Al6061-T6	Al2024-T3	Al7075-T6
Weight loss [g]	1.7898	0.0917	0.0114	0.0551	0.0564
Rcorr [$\text{g/m}^2\cdot\text{a}$]	650.6983	33.3384	4.1446	20.0321	20.5047
Classification	C5 (Very High)	C5 (Very High)	C4 (High)	CX (Extreme)	CX (Extreme)

Table B6. Summary of results from the 12-month exposure ASTM G1 mass loss test and corrosion classification per ISO 9223:2012.

	1010 Steel	CDA101	Al6061-T6	Al2024-T3	Al7075-T6
Weight loss [g]	3.843	0.1225	0.0164	0.1114	0.0706
Rcorr [$\text{g/m}^2\cdot\text{a}$]	698.5791	22.2680	2.9812	20.2503	12.8336
Classification	C5 (Very High)	C4 (High)	C4 (High)	CX (Extreme)	CX (Extreme)

Table B7. Annual Chloride deposition.

ASTM B-825 Silver Coupon (Ag)		
Chloride Deposition	1165.514	$\text{mg/m}^2\cdot\text{a}$

Corrosion severity site classification

The results from the ISO 9223:2012 analysis of weather data and mass loss testing (Table B5 and B6) suggest the CCAD site is a category 5 (C5) classification of atmospheric corrosion severity. Thus, the potential for corrosion at the site is considered very high.

Laboratory results for six-month coupon exposure

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MATERIALS TEST REPORT

Ref. D246720-2

Date September 2, 2016

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Larry Clark
Mandaree Enterprise Corporation
812 Park Drive
Warner Robins, Georgia 31088

Purchase Order #: W9132T-ATS-002-01

Procedure

Test Performed
Mass Loss Evaluation

Method
ASTM G1-03 (2011)

Test Material
Mass Loss Coupons

Requirements
None Specified

Results

Sample I.D.	Part #	Initial Weight [g]	Final Weight [g]	Δ Weight [g]	Mass Loss %
CDA101	COR124170304100	33.6182	33.5265	.0917	.2727
C1010	COR123750304100	29.8844	28.0942	1.7898	5.9904
AL6061T6	COR123400304100	10.1357	10.1243	.0114	.1124
AL7075T6	COR123470304100	11.0208	10.9644	.0564	.5117
AL2024T3	COR122990304100	10.6545	10.5994	.0551	.5171

ISO 9001

Prepared by: C. Elsberry
Materials Testing

Approved by: C. Tippens
Materials Testing

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ATS905B, 12/2015

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MATERIALS TEST REPORT**Ref.** D246720-2**Date** September 1, 2016**Page** 2 **of** 4 **Figure 1: CDA101 after Corrosion Removal** **Figure 2: C1010 after Corrosion Removal** **Figure 3: AL6061T6 after Corrosion Removal**

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MATERIALS TEST REPORT**Ref.** D246720-2**Date** September 1, 2016**Page** 3 **of** 4 **Figure 4 : AL7075T6 after Corrosion Removal** **Figure 5: AL2024T3 after Corrosion Removal**

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ACCELERATED ENVIRONMENTAL TEST REPORT

Ref. D246720-2	Date September 2, 2016	Page 4 of 4
Larry Clark Mandaree Enterprise Corporation 812 Park Drive Warner Robins, Georgia 31088		Purchase Order #: W9132T-ATS-002-01
Procedure		
<u>Test Performed</u> Coulometric Reduction of Surface Films on Metallic Surfaces		<u>Method</u> ASTM B 825-13
<u>Test Material</u> Silver Test Coupon		<u>Requirements</u> None Specified
Results		
Sample I.D.	Sample #	Observations
Ag	COR117520304100	Reduction Time = 1,670 Seconds Total Reduction Charge = 3.053 Coulombs

ISO 9001

 Prepared by: Lloyal Thomas
 Electrical Testing

 Approved by: Shawn Murray
 Group Manager

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Laboratory results for twelve-month coupon exposure

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MATERIALS TEST REPORT

Ref. D246720-6

Date December 16, 2016

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Larry Clark
Mandaree Enterprise Corporation
812 Park Drive
Warner Robins, Georgia 31088

Purchase Order #: W9132T-ATS-002-01

Procedure

Test Performed
Mass Loss Evaluation

Method
ASTM G1-03 (2011)

Test Material
Mass Loss Coupons

Requirements
None Specified

Results

Sample I.D.	Part #	Initial Weight [g]	Final Weight [g]	Δ Weight [g]	Mass Loss %
CDA101	COR124170304100	34.5033	34.3808	.1225	.3550
C1010	COR123750304100	29.0703	25.2272	3.843	13.22
AL2024T3	COR123400304100	10.1790	10.0676	.1114	1.094
AL6061T6	COR123470304100	10.0090	9.9926	.0164	.1638
AL7075T6	COR122990304100	10.8952	10.8246	.0706	.6479

ISO 9001

Prepared by: _____ C. Elsberry
Materials Testing

Approved by: _____ C. Tippens
Materials Testing

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ATS905B, 12/2015

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MATERIALS TEST REPORT**Ref.** D246720-6**Date** December 16, 2016**Page** 2 **of** 4 **Figure 1: CDA101 after Corrosion Removal** **Figure 2: C1010 after Corrosion Removal** **Figure 3: AL2024T3 after Corrosion Removal**

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MATERIALS TEST REPORT**Ref.** D246720-6**Date** December 16, 2016**Page** 3 **of** 4 **Figure 4 : AL6061T6 after Corrosion Removal** **Figure 5: AL7075T6 after Corrosion Removal**

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Ref. D246720-6

Date December 8, 2016

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Larry Clark
Mandaree Enterprise Corporation
812 Park Drive
Warner Robins, Georgia 31088

Purchase Order #: W9132T-ATS-002-01

Procedure

Test Performed

Coulometric Reduction of Surface Films on
Metallic Surfaces

Method

ASTM B 825-13

Test Material

Silver Test Coupon

Requirements

None Specified

Results

Sample I.D.	Sample #	Observations
Ag 2	COR117520304100	Reduction Time = 1,630 Seconds Total Reduction Charge = 3.185 Coulombs

ISO 9001

Prepared by: _____ Lloyaal Thomas
Electrical Testing

Approved by: _____ Mark Elrod
Manager

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Appendix C: Salt Spray Exposure Test Results

Note that the words “painted coupons” used in these results are referred to as “test panels” within the body of this report.

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SALT SPRAY EXPOSURE OF PAINTED COUPONS

ATS JOB # D246720-1

PURCHASE ORDER #W9132T-ATS-002-01

Prepared for

LARRY CLARK
MANDAREE ENTERPRISE CORPORATION
812 PARK DRIVE
WARNER ROBINS, GEORGIA 31088

Prepared by _____
Chris Elsberry, Materials Testing

Approved by _____
Clinton Tippens, Materials Testing

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ACCELERATED ENVIRONMENTAL TEST REPORT

Ref. D246720-1

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Subject

Salt Spray Exposure of Painted Coupons

Material

Painted Coupons

Background and Objective

Mandaree Enterprise Corp. submitted ten (10) scribed painted coupons for salt spray exposure to observe the corrosion resistance.

Test Procedure

The exposure was performed per ASTM B117-16, *Standard Practice for Operating Salt Spray (Fog) Apparatus*, for 2000 hours. The samples were removed after 1000 hours and evaluated for rust swell per ASTM D1654-08, *Standard Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments*, and photographed. After 2000 hours of exposure, the samples were removed and evaluated per ASTM D1654, Procedure A, Method 1 (Scraping), and photographed.

Requirements

None Specified

Results

Table I: Salt Spray Exposure Results			
Sample ID	Sample #	Rust Swell 1000 hrs. ASTM D1654-08 (mm)	Creep From Scribe 2000 hrs. ASTM D1654-08 (mm)
S22-7	1	5 (3.45)	10 (0)
S2-9	2	5 (3.47)	10 (0)
S13-1	3	7 (1.93)	6 (2.50)
S11-5	4	6 (2.24)	4 (5.13)
S21-5	5	6 (2.56)	5 (3.14)
S11-7	6	5 (4.18)	5 (4.27)
S12-1	7	5 (3.07)	5 (4.88)
S12-10	8	5 (4.34)	5 (4.56)
S13-8	9	6 (2.51)	10 (0)
S21-12	10	6 (2.32)	10 (0)

See Photographs on Pages 3-8

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Representative Mean Creepage From Scribe		
Millimetres	Inches (Approximate)	Rating Number
Zero	0	10
Over 0 to 0.5	0 to $\frac{1}{64}$	9
Over 0.5 to 1.0	$\frac{1}{64}$ to $\frac{1}{32}$	8
Over 1.0 to 2.0	$\frac{1}{32}$ to $\frac{1}{16}$	7
Over 2.0 to 3.0	$\frac{1}{16}$ to $\frac{1}{8}$	6
Over 3.0 to 5.0	$\frac{1}{8}$ to $\frac{3}{16}$	5
Over 5.0 to 7.0	$\frac{3}{16}$ to $\frac{1}{4}$	4
Over 7.0 to 10.0	$\frac{1}{4}$ to $\frac{3}{8}$	3
Over 10.0 to 13.0	$\frac{3}{8}$ to $\frac{1}{2}$	2
Over 13.0 to 16.0	$\frac{1}{2}$ to $\frac{5}{8}$	1
Over 16.0 to more	$\frac{5}{8}$ to more	0

Figure 1: Creep from Scribe Rating Chart

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Figure 2: Painted Coupons 1000 Hour Photographs

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Figure 3: Painted Coupons 1000 Hour Photographs

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Figure 4: Painted Coupons 2000 Hour Photographs (prior to scrape)

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Figure 5: Painted Coupons 2000 Hour Photographs (prior to scrape)

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Figure 6: Painted Coupons 2000 Hour Photographs (after scrape method)

APPLIED TECHNICAL SERVICES, INCORPORATED **ISO 9001**

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ACCELERATED ENVIRONMENTAL TEST REPORT

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Figure 7: Painted Coupons 2000 Hour Photographs (after scrape method)

Appendix D: Technical Data Sheet for VCI Primer Coating

As a result of this project and further testing of their own, Surtreat Holding, LLC formed a new company VCI Coatings, LLC to market a VCI-modified epoxy primer for maintenance painting over rust-covered and clean steel, as described below in company-produced literature.

VCI COATINGS, LLC

ANTI-CORROSION STEEL PRIMER

VCI PRIMER

PART A- MIL-DTL 24441 POLYAMIDE+ VCI AGENT

PART B MIL-DTL 24441 EPOXY HARDENER

PRODUCT DESCRIPTION

A two part polyamide epoxy containing a vapor phase migratory corrosion inhibitor (VCI Agent) in Part A resulting in a dry film containing 2.5% by wt. of the VCI Agent. The VCI Agent enhances the corrosion protection of the primer on both clean white and corroded rust covered steel. The VCI agent migrates in vapor phase through the rust layer and inhibits further corrosion on the white steel substrate.

RECOMMENDED USES

Maintenance painting over rust covered steel will provide level of corrosion protection equivalent to application of the same primer on clean white steel. High pressure water removal of loose rust is only required surface preparation. This significantly reduces cost in comparison to grit abrasion down to white steel condition that is required when using a zinc enhanced primer. It can be applied to clean steel as an alternative to zinc based primer systems.

PERFORMANCE

Accelerated performance of base primer in comparison to VCI Primer in salt fog chamber shows an average 50% reduction in the degree of undercutting and creep as measured by ASTM D1654 that can be extrapolated to a similar degree of extension in the performance life for the application of the VCI Primer covered with a high performance urethane finish. There is no reduction in the dynamic pull off adhesion of VCI Primer due to addition of the VCI Agent. VCI Agent can migrate in

into recessed areas, such as nut and bolt threads and flange overlap areas that are not in direct contact with the coating to inhibit further corrosion.

PRODUCT CHARACTERISTICS

- Excellent rust preventive properties in adverse or chemically polluted atmospheres
- Corrosion inhibiting properties increase coating system life time by a factor of 1.5 times.
- Easy to apply by brush, roller or spray
- Excellent adhesion to clean abraded steel and rust covered steel after cleaning with high pressure water.
- Can be used as a 2 coat primer and finish coat
- Compatible with most types of overcoat finishes
- Recommend top coating with a polyurethane for maximum durability

Color and finish	flat gray or green
Mass density	11.25 lbs. /gal.
Solids by volume	63%
Spreading rate @ 1mil DFT	1000ft ² /gal
VOC	2.8 lbs./gal.
Recommended DFT as primer	3-4 mils
Dry to touch	2-3 hours
Dry to hard	6-8 hrs.
Min/max interval for over coating	8 hrs. to 7 days
Flash point	100°F

SURFACE PREPERATION

Coating adhesion is the primary variable affected by surface preparation. For application to clean steel surface profile of 1 to 2 mils is recommended. For application on corroded and paint covered steel, remove loose rust and delaminated paint on surface by wire brush or water washing at 1500 to 2000psi. Dynamic pull off strength measured by ASTM D4541-09 shows 2000psi for clean white steel abraded at 1-2 mils and 1500psi for rust covered steel with loose surface rust removed.

APPLICATION PROCEDURES

- Thoroughly mix Parts A and B in exact 50/50 ratio by volume and 54/46 by weight
- Surface temperature must be above 40°F and dew point above 5°F
- Pot life is 5 hours at 73°F
- Apply using brush, roller or spray
- Conventional sprayer recommend is DeVibiss MBC or JAG 704E
- Airless spray recommend Graco 20-509 or Binks 5000 using 0.018 to 0.021 tips at 24psi
- Thin using MIL-24441 thinner at 5 to 10% for airless, 5 to 15% for conventional spray and brush and roller 0 to 5% by volume.

CAUTION

CONTAINS FLAMMABLE SOLVENTS. Keep away for sparks and open flames. Use only grounded explosion proof equipment in accordance with the National Electric Code. Workmen must use non-ferrous tools, wear non-conductive and non-sparking shoes in areas where explosion hazards exist. In confined areas workmen must wear fresh airline respirators, protective clothing and gloves. Avoid contact with skin, breathing vapors of spray mist. Keep out of reach of children. Read the supplied Safety Data Sheet before proceeding with mixing and application.

DISCLAIMER AND WARRANTY

The technical data provided here is offered as a guide and it is expected that the VCI Primer will only be used by professional painters experienced in using solvent based coatings. VCI Coatings has no control over the application conditions or procedures used and will only warrant that the delivered primer meets the listed specification of contents and will only warrant replacement if not in specified condition on delivery.

VCI Primer MIL 24441

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14. ABSTRACT This project demonstrated the capabilities of a vapor-phase corrosion in-hibitor (VCI) as an additive into an epoxy primer coating for exterior hangar doors in a severely corrosive environment. Typically, protective coatings used on steel structures use zinc-loaded primers to provide cor-rosion protection to the substrate. As a more environmentally friendly option, a VCI-modified coating system has been used instead of a zinc-containing primer. The VCI migrates to the steel substrate to form a mi-croscopically thin, corrosion-inhibiting film. The demonstrated coating system was also applied to test panels exposed to atmospheric weathering and to laboratory salt-fog exposure testing. The VCI-modified coatings were applied to abrasive-blasted substrates and to surfaces without the rust fully removed. Although the VCI-modified coating system showed promise in the test panel exposure results—especially panels with a lower grade of surface preparation—it was unable to protect the steel doors due to high levels of mechanical damage they incur during normal site opera-tions. Based on the test panel results, further evaluation of the VCI-modified coating system is considered necessary before making a positive recommendation for Army and DoD implementation. Due to the results of this demonstration, the project return on investment was zero.					
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